DOTTORATO IN AMBIENTE E TERRITORIO

XXVI CICLO

TESI DI DOTTORATO

Impacts of Advanced Travel Information Systems on Travel Behaviour

Smartmoov' case study

Tutor:

Prof.ssa Cristina Pronello

Dottorando:

José Pedro Ramalho Veiga Simão

Politecnico di Torino

Interuniversity Department of Regional and Urban Studies and Planning (DIST)

May 2014

SSD: ICAR/5 – Transport

"Guio-me pela minha cabeça, nunca fui servo de ninguém. Aprendi a viver com o granito, não dobro."

In memoria del nonno Veiga Simão

(1929-2014)

Table of contents

List of symbols and Acronyms

ATIS - Advanced Travel Information Systems

ATT – Attitudes towards behaviour

AVL - Automatic Vehicle Location

Autolib – Lyon Car sharing programme

Bac - Baccalauréat

CI – Confidence Interval

CO_2 – Carbon dioxide

DRM – Motorcycle (Deux roues moto)

EC – European Commission

ETC - Electronic Toll Collection

EU - European Union

ITS - Intelligent Transport Systems

GDP – Gross domestic product

GPS - Global Positioning System

N – Number of participants

NO_x - Mono-nitrogen oxides

M – Mean value

Mdn - Median

OECD – Organization for Economic Co-operation and Development

p – p-value

PCB – Perceived behaviour control

PSTP - Puget Sound Transportation Panel

PT – Public Transport

r_s – Spearman Correlation

RDS - Radio Data System

RITA - Research and Innovative Technology Administration

SD – Standard deviation

SN – Subjective norms

TER - Transport express régional

TPB - Theory of planned behaviour

UK – United Kingdom

US – United States

Velov' – Lyon Bike share programme

VMS - Variable Message Signs

α – Cronbach's Alpha

Figures

Tables

Executive Summary

Transport of goods and people is an important driver of the global economic growth and prosperity because it enables trading and people connectivity.

In Europe, in 2011, the transport sector is responsible for the 33% of the final energy consumption and for approximate 5000 million tonnes of CO_2 equivalent of greenhouse gases per year, being the tendency the continuous growth of these numbers.

This leads us to the major question that transport research groups have been trying to answer for years: how to maintain the freedom and prosperity that transports give to today's society without increasing air and noise pollution, congestion, fatalities, and greenhouse gases. The goal is to make the mobility more efficient and sustainable, both for passengers and goods, being one of the basic pillar in the new economic growth paradigm in a low carbon world.

One of the current challenges to face the is to use the Advanced Traveller Information Systems (ATIS), notably the multi-modal solutions, to make the mobility more efficient and sustainable. These systems are seen as an encouragement for travellers to make the best use of the available transport modes and to support an integrated, sustainable transport system throughout Europe.

Under this vision, large amounts of money have been invested to implement in the cities such systems, but, until now, few assessments have been done to verify if it contributes to a real modal shift and, in the higher end, to a more sustainable mobility.

This research aims at thoroughly assessing the effectiveness of multimodal real-time information systems, pointing out the limitations before their use and recording the changes induced on the travel behaviour.

Two wave questionnaires were designed and administered before (50 participants) and after (46 participants) a five months experimentation; a multimodal real-time information application for Smartphones (Smartmoov') was tested after being implemented in the city of Lyon, in 2013. Besides the questionnaires, twelve focus groups were conducted with the same sample, six before and six after the experimentation. The survey was aimed at investigating the potential changes of travel behaviour of the sample. Descriptive analysis, parametric and non-parametric tests, factor analysis and binary logistic regression were used as statistical approaches to analyse the collected data and evaluate the effectiviness of Smartmoov'.

Before the experimentation, it was understood that participants had no constrains towards the use of the Smartmoov', being its use under a positive outlook: almost everyone was expert in the technology and was familiar with the concept of Smartmoov'.

The travellers' assessment of the travel planner was initially modestly positive, but it decreased over time and, after the experimentation, the use of the different modes remained stable while a small increase of the car for the most frequent trip was observed.

The perceived behaviour control and the intentions to change mode did not show variations after the experimentation; this fact points out that the behaviour is not completely reasoned, being partly under the influence of the habitual performance.

The stability of the mode used, of the perceived behavioural control and of the intentions show that mobility is strongly influenced by the high frequency of the past behaviour. In fact, the mobility habits are a heavy burden on the process of modal choice. Nevertheless, information can play a role on modal shift, but only if it is strong enough to interrupt the patterns of routine commutes.

Literature observed that, to induce the use of these systems, travellers ask that they are user-friendly, with accurate information and a good graphical design. The negative evaluation of Smartmoov' after the experimentation can be due, partly, to the software himself, where the general overview of the participants was that Smartmoov' app was not easy-to-use, facing problems to use it during the daily commuting.

Nevertheless, the results of the experimentation were in line with previous studies; few people used this app on a daily basis or for planning daily commuting, but they most often used Smartmoov' to plan occasional travels. Furthermore, people did not show any willingness to pay to use Smartmoov' neither before or after the experimentation.

Provision of information, by itself and alone, showed little or no impact on the efficiency of the urban transport network. Therefore, much work has to be done in parallel with the development of these systems for the promotion of sustainable commuting; for instance, improving sustainable transport infrastructures, increasing anti-car policies and promoting the education towards mobility.

In this research the TPB model was applied as approach to explain the modal diversion induced by the use of real time information; however, this model did not fit the behaviour, probably due to the small sample. Thus, this theory will be applied to a larger sample, using the findings of this research for the factor constructions. To this extent a new research project (Opticities: www.opticities.com) has started investigating the same issue, but working with a sample of 150 persons in each of the six cities involved in the project. The new data will be used to test, other behavioural models to try to explain the modal shift in case of multimodal real time information. Finally, a mix of models or a new model could be built to describe and explain the complex people behaviour.

Introduction

Every day a vast number of people and enormous volumes of products and raw materials are transported over long, medium and short distances to enable the global economy. This flow of goods and people is an important driver of the global economic growth and prosperity, therefore the worldwide tendency is towards exponential continuous growth of transport. The European Union (EU), since the establishment of Schengen agreement in 1985, permits a free flow of people and goods in the European Union area and both Member States and their citizens gained prosperity and better living conditions (Brasoveanu et al., 2010). As a matter of fact, the data provided by the World Bank (2013), shows that GDP growth on the EU-27 is highly correlated with road energy consumption (Figure 1) (r_s = .916, p <.001).

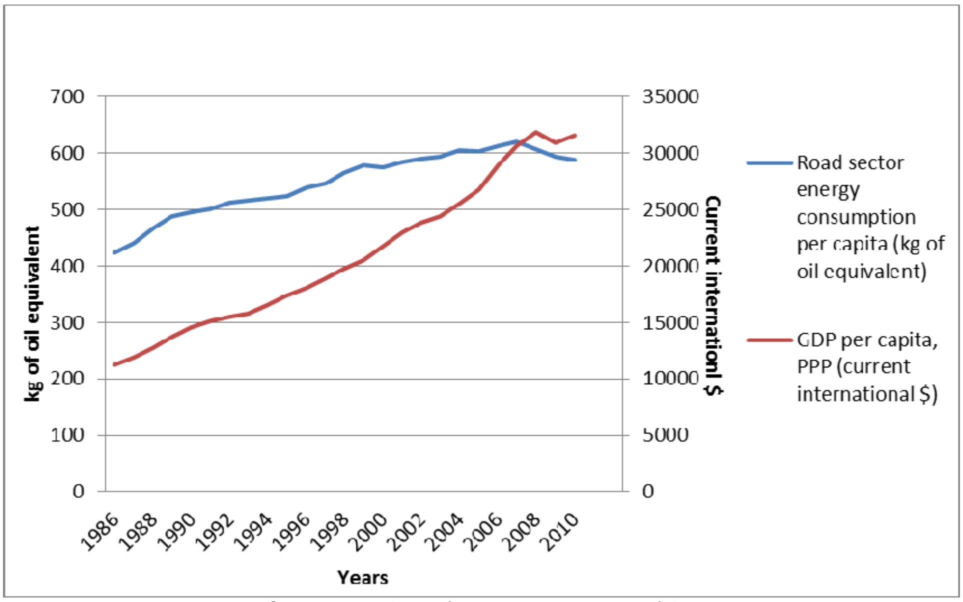


Figure 1 – EU-27 road energy consumption and GDP

Adapted from: The World Bank, 2013

People living in the European Union have grown surrounded by an intensive transport network that allowed the redistribution of production assets and people's knowledge and experience, being a key factor for the level of prosperity that this region has reached (de Ven and Wedlock, 2011).

Nowadays the mobility in Europe is very developed; almost everywhere there are good road and rail connections between and within cities. This fact does not mean that the European citizens take the best of the services supplied and that the mobility in European countries is sustainable. In fact, as shown in the Figure 2, the transport sector is responsible for almost 1/3 of the energy consumption in Europe.

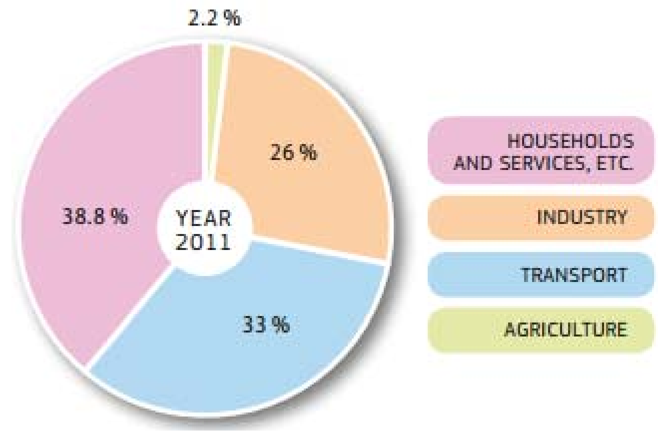


Figure 2 - EU-27 Final Energy Consumption by sector in 2011

Source: European Commission, 2013

It is evident that transports are an unsustainable sector, mainly because the major share of both passenger and freight transports within the EU is covered by road transport, that has been growing almost continuously over the last decades. Despite of the current crisis, it is expected that road transport will continue to increase (European Commission, 2013). Moreover, it is also expected that road transport demands will increase much stronger than for other modes (de Ven and Wedlock, 2011).

The main downside of European intensive and ever growing road transport is also well known. According to the speech given in the opening ceremony of the Transport Research Arena, at Ljubljana 2008, by the European Commissioner for Science and Research Janez Potoènik:

- road congestion costs on average 1 % of Gross domestic product (GDP) in the EU;
- road transport accounts for 72 % of all transport-related CO_2 emissions, as illustrated in the Figure 3, which have increased by 32 % in the period 1990-2005. In spite of continuous improvements in the fuel efficiency of vehicles, CO_2 emissions from transport are expected to grow by a further 15% by 2020;

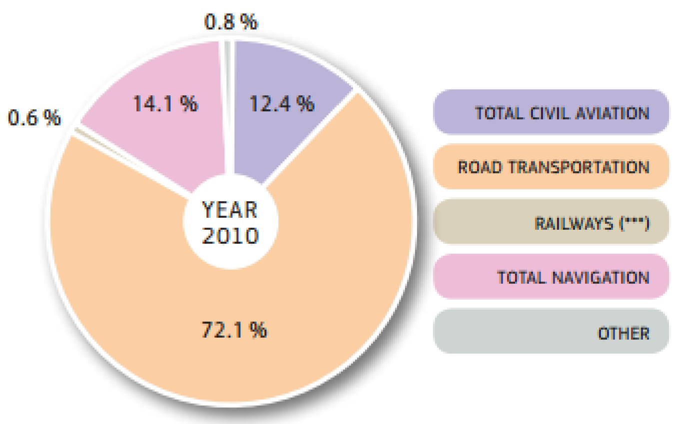


Figure 3 - EU- 27 GHG Emissions from Transport by mode

Source: European Commission, 2013

- road transport has a major share in other negative environmental effects, such as NOx emissions, fine dust and noise;
- in the EU, 73% of all oil (and about 30% of all primary energy) is consumed by the transport sector;
- road fatalities still amount to 35,000 in 2009. This is far above the EC target set in 2001 to reach 25,000 fatalities in 2010 (a 50 % reduction from 2001). The target of halving the overall number of road casualties in the EU by 2020 has just been renewed.

As a matter of fact, this leads us to the major question, that transport research groups have been trying to answer for years, that is to understand how to maintain the freedom and prosperity that transport give to today's society without increasing air and noise pollution, congestion, fatalities, and greenhouse gases. The goal is to make the mobility efficient; a more sustainable transport system for passengers and goods is a basic pillar in the new economic growth paradigm in a low carbon world (UK Department for transport, 2007).

Quoting the European Commissioner for Science and Research Janez Potoènik (2008) "(..) for building a sustainable transport system it is needed a systemic approach, an approach that links vehicles, infrastructure and users, and that links users with other users."

For the World Road Association, 2002, this means:

- maximize the capacity of transport infrastructure;
- optimize traffic flows;
- integrate safety solutions;
- develop new intelligent mobility systems for urban environments;
- improve links between different transport modes.

The scope of this research is related to the last two topics, following the idea that the use of Advanced Traveller Information Systems (ATIS), especially the multi-modal solutions, is a key element in the answer to the challenge of accommodating the increasing demand for road transport while reducing road fatalities, congestion and environmental impacts. These systems are seen as an encouragement for travellers to make the best use of the available transport modes and to support an integrated, sustainable transport system throughout Europe (de Ven and Wedlock, 2011).

In other words, travel information can benefit the transport network in terms of lower incident-induced congestion (with accompanying increased safety and decreased travel delay), higher accessibility to destinations and modes, lower fuel consumption and improved air quality (Williams et al., 2008).

In response to these known ATIS benefits for individuals and transport systems, many cities and countries have deployed ATIS technologies. Although transport agencies experience and customer satisfaction with ATIS deployments have generally been positive, methodologies for quantifying the benefits and costs of ATIS are lagging behind (Williams et al., 2008). This fact has been brought into keen focus by increasingly constrained transport budgets.

The purpose of this research project is to measure the impacts of ATIS on travel behaviour. To this extent, we will analyse the implementation of the Smartphone application Smartmoov', a multimodal tool developed within the Optimod'Lyon project, in the city of Lyon (France), collecting data about the travellers' behaviour before, during and after the introduction of this tool. The innovation of this dissertation is the approach followed to get the data and the ex_ante and ex_post monitoring to understand the real impact of the introduction of ITS technologies on travellers' behaviour.

This research has been carried out within the project Optimod'lyon and it is articulated in two major steps:

1. a first study using a quali-quantitative approach which allowed to evaluate the attitudes and the behaviours of 50 participants before the use of Smartmoov',;
2. a second study, quasi-experimental, with qualitative and quantitative measures repeated in pre-test and post-test with 46 participants, to understand the impact of the introduction of ATIS on the mobility of participants, notably of Smartmoov'.

After this introductory chapter, a detailed literature review is made in order to understand the relation between Advanced Traveller Information Systems (ATIS) and traveller's behaviour. Therefore, the chapter I gathers information about Intelligent Transport Systems (ITS), particularly Advance Traveller Information Systems (ATIS) and is divided in two parts: a brief overview about the Intelligent Transport Systems (ITS) and an extensive analysis of Advance Traveller Information Systems (ATIS), where it is explored: (1) what and where they have been used; (2) what are and how the impacts on the travellers behaviour have been measured; and (3) their future tendencies.

The chapter II focuses on the Theory of Planned behaviour; this theory was selected as basis for the behavioural analysis. The chapter explores the concepts of this theory and a meta-analysis is made based on some case studies.

The literature review continues with the chapter III where the issues analysed in the chapters I and II are crossed. In this chapter, case studies are analysed to study the effects of ATIS on travellers' behaviour and some conclusions given to understand the influence of ATIS on travellers' behaviour.

The Chapter IV is devoted to describe the methodology adopted in the two studies, explaining how the data were gathered and which statistical assumptions and treatments were carried out.

The Chapter V reports the results of the two studies. The first study focuses on participants mobility habits and on the attitudes related to the use of the real-time information system before the use of the Smartmoov' app. Afterwards, the second study, identifies the differences on travellers' behaviour after a five month experimentation of Smartmoov'.

Chapter VI presents the discussion giving a critical analysis of the research and the conclusions summarizes the results of both studies discussing the use of ATIS, notably the Smartmoov' app, and the future researches that can be made as follow up of this study.

Chapter I – Transport Information Systems

Information technology (IT) has transformed many industries, from education to health care to government, and is now of transforming transport systems. Nowadays improving a country's transport system does not solely mean to build new roads or repair aging infrastructures; the future of transport lies not only in concrete and steel, but also increasingly in using IT (Ezell, 2010).

IT enables elements within the transport system (vehicles, roads, traffic lights, message signs, and others) to become intelligent by embedding them with microchips and sensors and empowering them to communicate with each other through wireless technologies, the so called Intelligent Transport Systems (ITS).

With the evolution of these systems and in the framework of today's information society, grown the concept of Advanced Traveller Information Systems (ATIS). ATIS intend to make available real time information regarding the trip such as the traffic conditions, weather, time of commuting or the occurrence of unanticipated incidents (Hyejung, 2009). However, the potential for ATIS of influence the mobility behaviour has hitherto rarely been research (Gotzenbrucker and Kohl, 2011).

Being the goal of this research, the study of the influence that advance traveller information systems (ATIS) have on the traveller behaviour, the first step is to know these systems (Chapter I). The first sector is devoted to the general Intelligent Transport Systems (ITS); while the second focuses on the Advanced Traveller Information Systems (ATIS), mainly related to the modes where they have been implemented; the third section gathers information about the theoretical benefits of the ATIS.

1. Intelligent Transport Systems (ITS)

The term Intelligent Transport Systems (ITS) refers to information and communication technology applied to transport infrastructure and vehicles, that improve transport outcomes such as transport safety, transport productivity, travel reliability, informed travel choices, social equity, environmental performance and network operation resilience (World Road Association, 2002). In Figure 4, the concept of ITS is presented:

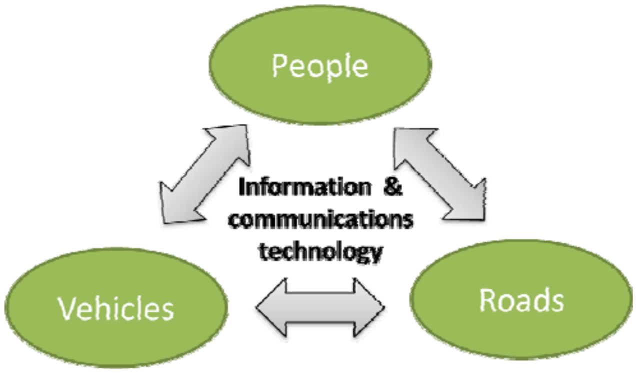


Figure 4 – Conceptual diagram of ITS

Source: Takeuchi and Maeda, 2007

This term ITS has been used since the mid-80s, pulled by the work carried out by the Japanese researchers, and includes a large number of technologies and systems in various stages of development, from research prototypes, or even concepts, to commercially available products and applications (Giannopoulos, 2004; Kumar et al. 2003).

In Japan, a navigation system name Comprehensive Automobile Traffic Control System was implemented already in the early 1970s, but "it seemed too early to be accepted in public" (p.1). Then, from the middle of 1980s, several ITS projects such as Road/ Automobile Communication System, Advanced Mobile Traffic Information and Communication System and Super Smart Vehicle System were initiated (Kuwahara, 1998).

Since the 1990s, ITS saw a rigorous development, such in terms of prototype technologies, systems and their application. Notions such as the "intelligent vehicle", the "intelligent highway", or "smart real time traffic monitoring and control", were introduced for the first time to express the increasing "intelligence" and dynamic nature of the systems that were introduced (Giannopoulos, 2004).

A major research effort on the part of the EU has initiated in 1988 within the DRIVE of DG XIII (now DG INFSO) having the main objective to support the application of new technologies in the field of the transport sector (road transport in the very beginning) for improving safety and efficiency. From 1994 till 1998 a big effort was made in this area with the launch of the Telematics Applications Programme (TAP) under the 4th Framework Programme for Research, Technological Development and Demonstration, with the specific programme for Transport Sector of TAP (TAP-T); altogether 118 projects have been selected for funding for over 200 Million Euro. The projects developed and validated telematics technologies and applications that provide enhanced services to transport users through improved efficiency, safety and environmental quality, taking into account policy objectives of the European Union (Keller, 1999).

The European effort continued until today through the EU Framework Programs (FPs) of research, following the publication of the ITS Action Plan (COM(2008)886) and the Directive 2010/40/EC. The ITS Action Plan is made in partnership with Member States and European road operators, service providers and industry to provide the efficient, safe, and environmentally friendly intelligent transport systems which best serve the needs of society.

In the United States of America, the Research and Innovative Technology Administration (RITA) Department of Transportation proposed to divide the ITS into intelligent infrastructures and intelligent vehicles. The Table 1 offers a concise overview of the ITS applications according to the division proposed by RITA (2013).

Table 1 – Overview of the intelligent transport applications

Intelligent infrastructure		
Arterial and freeway management • Traffic signal control, lane management. • Surveillance, enforcement.	**Crash prevention and safety** • Warning systems. • Pedestrian safety.	**Traffic incident management** • Surveillance, detection. • Response, clearance.
Emergency management • Hazardous material management. • Emergency medical services.	**Electronic payment and pricing** • Toll collection. • Multi-use payment.	**Roadway operations** • Asset management. • Work zone management.
Transit management • Operations and fleet management. • Transportation demand management.	**Traveller information** • Pre-trip and en-route information. • Tourism and events.	**Road weather information** • Surveillance and prediction. • Traffic control.
Information management • Information warehousing services. • Archived data management.	**Commercial vehicle operations** • Carrier operations, fleet management. • Credentials administration.	**Intermodal freight** • Freight and asset tracking. • International border crossing.
Intelligent vehicles		
Collision avoidance • Obstacle detection. • Collision-avoidance sensor technologies.	**Driver assistance** • Navigation, route guidance. • On-board monitoring.	**Collision notification** • Advanced automated collision notification. • In-vehicle crash sensors.

Source: RITA, 2013

2. Advance traveller information systems (ATIS)

Advanced Traveller Information Systems (ATIS) are one of the user services provided by ITS, based on technologies that highlight the importance of the short-term prediction of traffic flow, to take decisions in traffic management and properly inform the users (Casas Vilaró, 1998).

For that reason Advanced Traveller Information Systems (ATIS) allow travellers to plan their route and estimate their travel time (Nagaraj, 2011), as well as to take better decisions to improve the convenience, safety and efficiency of their travels (Shekhar and Liu, 1994.). ATIS can be viewed as a data integration system that delivers accurate, reliable, and timely information to travellers (Hyejung, 2009).

For Ezell (2010) ATIS include the following Specific ITS Applications: Real-time Traffic Information; Route Guidance/Navigation Systems; Parking Information; Roadside Weather Information Systems, and Real-time Public Transport Information.

ATIS applications, in the last decades, have been among the most popular issues for transport analysts and many models have been proposed and discussed. This fact is due to the expectation of many specialists to solve with technological investments several of the oversaturation problems concerning traffic and pollution (Simonelli and Bifulco, 2005).

The Figure 5 illustrates the three key facets to the provision of real-time traffic information: collection, processing, and dissemination, with each step entailing a distinct set of technology devices, platforms, and actors, both public and private.

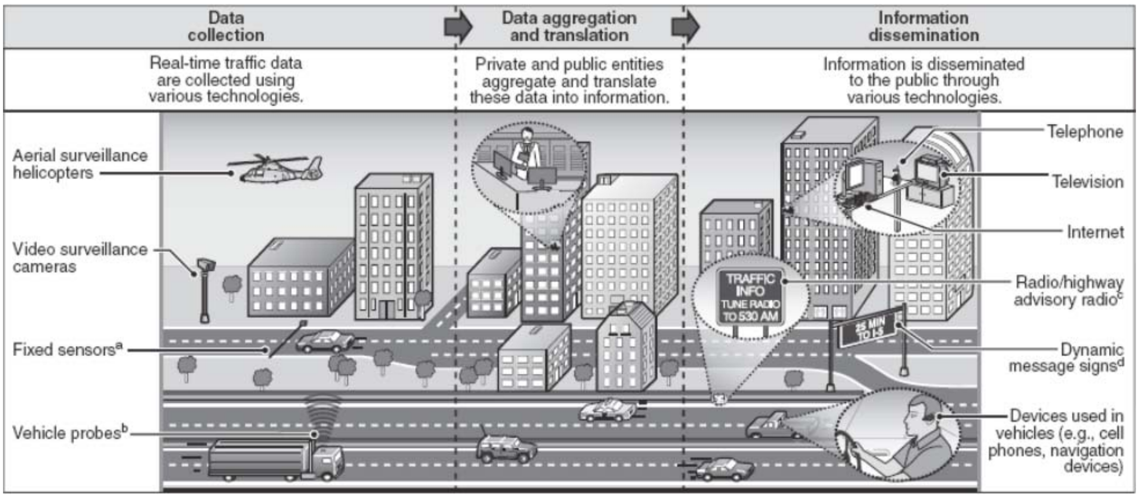


Figure 5 - Technologies associated with real-time Traffic Information systems

Source: Ezell, 2010

Lively and Elhamshary (2005) described ATIS under three decision-making scenarios:

- *Pre-trip planning*

Travellers use pre-trip planning to decide the time to start the trip and to select a route and/or travel mode. Considerations include traffic and weather conditions, the availability of public transport, rail service, bicycle options, or finding someone to rideshare with.

- *En-route*

During the trip, motorists may seek advice about location of rest stops and support facilities, parking, road restrictions, incidents/backups, weather conditions and intermodal connections such as arterial-to-highway, park and ride to public transport, etc.

- *Re-routing*

Travellers already aware of weather conditions or congested locations use ATIS to find alternative open and timely routes/travel modes to complete their trips. Such information reduces incident-related congestion, secondary incidents, and stress or road rage. ATIS may be intermodal, such as the system used by Amtrak (American Train Company) where passengers can consider to use the bus after a freight derailment delays their train.

The Research and Innovative Technology Administration (RITA) created and feed the ITS Benefits Database. This Database gathers and divides information about the benefits of ITS on mobility (RITA, 2013). The Table 2 summarizes the results of the findings of the database highlighting that traveller information systems have demonstrated the ability to improve users mobility. The ATIS also enhance network traffic distribution, improving effective capacity and reducing fuel consumption and related emissions. Several evaluations have also documented positive customer satisfaction ratings (Maccubbin et al., 2008).

Table 2 - Traveller Information Benefits Summary

	Safety	Mobility	Efficiency	Productivity	Energy and Environment	Customer Satisfaction
Pre-Trip Information		+	+		+	++
En-Route Information		+				++
Tourism and Events						++

Adapt from Maccubbin et al., 2008 Legend:+ Positive impacts; ++ Substantial positive impacts

2.1. ATIS for Car

The first documents referring to information systems for drivers were the Variable Message Signs (VMS) on the early 1960. VMSs are traffic control devices used for traffic warning, regulation, routing and management, and are intended to affect the behaviour of drivers by providing real-time traffic-related information. The first VMS was set up with permanent, semi-static displays, lighting up when a recurrent weather or accident condition ahead on the road happened. Currently VMSs are programmable traffic control devices that can usually display any combination of characters to present messages to motorists. Today they display information about incidents, roadworks, weather conditions, and estimate the time needed to get to a certain destination. These signs are either permanently installed above or are on the side of the roadway or portable devices attached to a trailer or mounted directly on a truck and placed at a desired location (Dudek, 2004).

Another early information system for drivers was the HAR (Highway Advisory Radio). This system first started on the roads accessing to the Los Angeles airport in 1972. The roadside broadcasting stations of HAR provided traffic conditions to vehicle drivers. After the evaluation project of HAR in Minneapolis, Federal Highway Administration (FHWA) actively promoted HAR, especially on highways around the major transport terminals (Burden, 2012).

In Germany, ARI (Auto-fahrer Rundfunk Information), a highway radio system using FM (Frequency Modulation), was introduced in 1974 to alleviate traffic congestion on north-bound autobahns during summer holidays. Similar systems were developed in various countries in Europe; they employ RDS (Radio Data System) which can insert several additional data to available vacant spaces in the FM wave as the multi-layered data. The RDS started to be commonly used to provide traffic information and hence the system is called RDS-TMC (Traffic Message Channel). Today the RDS can be programmed to interrupts in–vehicle radio broadcasts and cassette players to bring news about roadworks, accidents, adverse weather or other incidents likely to cause delay.

In 1978, in France, the Minitel system started the provide information using telecommunication, then followed by other countries: the Captain system in Japan and VideoText in USA and UK. These systems delivered information (pages of text) to a user in computer-like format, typically to be displayed on a television. On the transport matter, these systems gave information about the traffic-state on highways and incidents (Harvey, 1998).

On the late 1980's Electronic Toll Collection (ETC) systems have been in operation. These systems consisted in automatically charge and collect tolls through a bi-directional communication between a vehicle on-board unit and a station. The first examples were the Trondheim toll road, the Orlesand tunnel in Norway and the Lincoln tunnel in the United States. Normally this system employs the flat toll pre-paid system, but it is possible to find the flat toll as well as distance based post-paid system like the Telepass used by at Autostrade in Italy or Autoroutes in France. Today the ETC is implemented in almost all major highways in the world. Recently this system has been adapted for charging vehicles entering in cities, as the case of "London congestion charge".

On April 1996 in Tokyo and Osaka a more advance information system was implemented: the Vehicle Information and Communication System (VICS), that is considered the first In–vehicle navigation systems. VICS Center receives real time traffic information from the Highway Traffic Information Center, which gathers the information from each of the highway authorities. VICS Center provides the information through roadside beacons as well as FM broadcasting. Two types of beacons were used: the microwave beacon on motorways and the infrared beacon on surface streets. The Figure 6 shows how this service worked. There was an on-board device (A) that is updated with traffic information and later with parking information when crossing the Infrared Beacon (B) or Microwave Beacon (C) (Kuwahara, 1998).

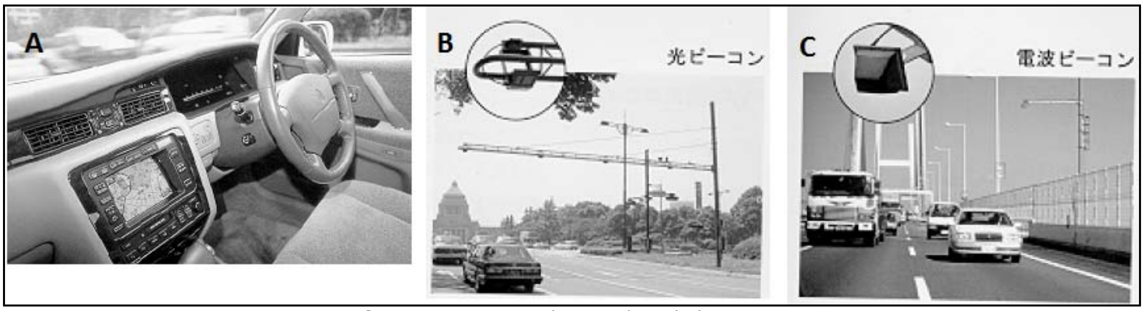


Figure 6 - An On-Board Unit and Roadside Beacons

Source: Kuwahara, 1998

The global positioning system (GPS) was hailed as a technological success soon after it became fully operational in 1995. With the improvements of the system and in particular with the discontinuation of the selective availability feature in May 2000, many commercial applications were beneficiate, many related to transport information systems, like the GPS-Navigators.

The GPS-Navigators are autonomous systems, which use digital maps and a direction finder (either by dead–reckoning or GPS) within the vehicle, to show where the vehicle is, on a small display within the driver's range of vision (Harvey, 1998). So the primary services of ATIS included pre-trip and/or en route traveller information concerning traffic conditions, route guidance, and "yellow page-type" information related to travelling as well as entertainment, dining and other services.

With the rapid progress in the development of communication technologies, notably internet and smart-phones, the current information services provides to travellers real-time information about traffic conditions, incidents, construction, public transport schedules. Thanks to these technological advances, the same types of information given by highway panels are currently available directly in the vehicle allowing to select the route on and to choose in real time the best option.

2.2. ATIS for Public Transport

At the beginning, public transport information consisted in giving only generally and not customized information at the PT stops, as timetables and line maps.

Then the firsts interactive information systems designed to assist travellers making pre-trip travel planning for one type of transport appeared. An example is the primitive journey planner at Heathrow Central tube station, at the early's 1990's: that basically had a huge (approx. 6ft x 4ft) tube map mounted on a slanted table with little bulbs in place of the station ticks or interchange circles and the people had a set of push buttons, one for each tube station, and pressing one of these would cause a sequence of the lights to show you the best route to that station. After that, the first ATIS applied to the public transport sector, providing the information available at the bus stops to the company's websites (Tang and Thakuriah, 2012). However, this information continued to be not customized and presented only estimated times of arrival. Examples of this practice were the websites that gave to the user information about the best route from point a to b. Those services were available just at home, work, and other major sites where trips were originated. Later on, information on road network conditions, incidents, weather and PT services, are conveyed through these systems to provide travellers with the latest conditions in order to plan their travel. Based on this information, the traveller could select the best departure time, route and modes, or perhaps decide not to make the trip at all (RITA, 2013).

The progress in database and web services facilitated the development of more specific query options for both customers and PT agencies. Starting in the early 2000s, many transit agencies in the United States began to offer static information on mobile devices, including timetables, service alerts, and trip planning (Transportation Research Board, 2011). This meant that users could use custom applications tailored to obtain explicit information, such as to identify all services available near a given location or to produce customized timetables (Hwang et al., 2006). This system included two major phases: one for the users and the other for the PT agencies. The users can request information about all buses, routes, timings of buses and all stops in any particular route, using Wi-Fi or GPRS technology from his computer and mobile. The PT agencies have to update, delete and insert information about all buses, routes, timings of buses, all stops in any particular route and helpline numbers (Nagaraj, 2011).

Automatic Vehicle Location (AVL) played a strong role in the advancement and spread of Intelligent Public Transportation. This AVL determines the position of a vehicle and transmit its location information back to a requester. Then the requester uses the positional information and complex algorithms to predict arrival and departure times of vehicles in the fleet (Gillen and Johnson, 2002). This allowed the appearance of En-Route services in the middle of 2000's mainly through SMS services. This SMS service gave information about the traffic of a specific route, about the next public transport stopping at one specific station and about accidents, traffic jams and weather (RITA, 2013).

The next step was the use of the Global Positioning System (GPS) devices, based on automatic vehicle location (AVL) technology, allowing to position in real-time buses, trams and subway. This system allowed to collect information, such as the current location and expected arrival time of the vehicles at a specific stop, in real-time (Gillen and Johnson, 2002).

Therefore, in 2008, many local authorities in the U.S. and Europe used a form of virtual dissemination to make real-time passenger information available to the public. The two most common options were SMS and the local authorities' website service (Transportation Research Board, 2011). An example is the "track by text" in Chicago that allowed customers to receive the arrival times of the next two buses at their bus stops via text messaging (Tang and Thakuriah, 2012).

The improvement GPS devices related to the rapid progress in the development communication technologies (notably internet and Smartphones) allowed the PT authorities to give real-time information to the passengers. The improvements in the speed and accessibility of wireless communications changed the way in which transit agencies are able to provide information to travellers. Now agencies, PT staff and customers can access to information at bus stops and on-board.

Nowadays a technology that facilitates the provision of real-time information is the trip-planning software. One of the first's mobile trip-planning applications using real-time information was deployed in Austria (SCOTTY). This mobile application available from ÖBB-Personenverkehr is a mobile route planner that provides timetable information, retrieves regional maps, saves personal timetables, and provides real-time information on specific connections. Another mobile application (trip planner) using real-time information was developed for Verkehrsverbund

Berlin–Brandenburg (VBB), which is the public transport authority of the Berlin–Brandenburg region in Germany. VBB-Fahrinfo is VBB's traveller information system that provides information through both Internet and mobile devices. After the deployment of this system the percentage of requests from mobile phones raised from less than 1% in January 2008 to around 13% in January 2009 (Transportation Research Board, 2011). Today, almost all large and some medium European transport agencies have their own trip-planner providing real-time information through internet and mobile devices.

Currently data, both static and real-time information, are available to the software developers community who have developed several apps that can be downloaded, for free or a fee, to handheld devices and Smartphones. Such a trend weakness the role of transport operators in providing information services while strengthen their role in providing data and in standardization. Also the private sector and/or regional governments are increasing their roles in providing information to the travellers (Biernbaum et al., 2011).

Today Advanced Traveller Information Systems (ATIS) give PT information to traveller through various channels such as Dynamic Message Signs (DMS), Internet website, and Smartphones apps. The internet has become a major travel information mean, supporting both pre-trip planning and en-route decision making. Bunch et al. (2011) carried out a survey between 2007 and 2010 in large US metropolitan areas having a population of one million or more. The study shows for the first time that traveller information based on infrastructure systems such as radio and dynamic message signs (DMS) are migrating to in-vehicle messaging through mobile devices and social media, such as Twitter (Figure 7).

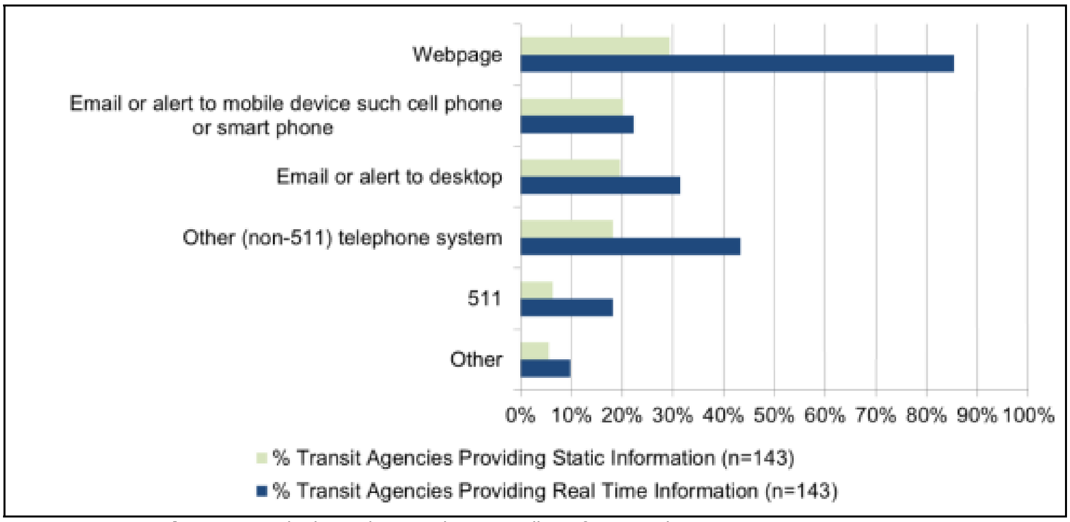


Figure 7 - Methods Used to Distribute Traveller Information by PT Management Agencies.

Source: Bunch et al., 2011

Mobility agencies are now focusing on the dissemination of more real-time data more than static information. With this progress, traveller information systems are not only able to benefit travellers, but also utilized as an add-value for the mobility agencies, for example when planning routes and frequencies (Chun-Hsin Wu et al., 2003).

The later tendency is to integrate the transport planning agencies on the application Transit on Google Maps. This application is a public transport planning tool, either for mobile or desktop, that combines the latest agency data with the power of Google Maps; it integrates transit stop, route, schedule, and fare information to make trip planning quick and easy for everyone. To the present day more than 500 cities have join this platform (Google, 2013).

2.3. ATIS for Bike Sharing

With the technological developments of the last decade bike sharing programs have seen a sharp increase in their popularity worldwide. This proliferation is mainly due to schemes to track the bike's movement through the network, as global positioning system (GPS), allowing operators to track movements, between docking stations. Contemporary bike sharing programs refer to the provision of bicycles to enable short-term rental from one docking station to another. In 2007, Paris launched Europe's largest scheme, with over 20 000 bicycles, in 2008 Torino launched its [TO]bike program and today counts 880 bicycles. In China, Wuhan and Hangzhou, have currently the world's largest public bicycle share schemes, respectively with 70 000 and 65 000 bikes. New York City launched the North America's largest bike share program, with 10 000 bicycles in 2013 (Fishmana et al., 2013). Fishmana et. al (2013) provide a comprehensive assessment of bike sharing the results show that mode substitution from cars to bike sharing is low being more often use as substitution of walking and public transit. Therefore, these programs have been seen as support for multimodal transport connections, by acting as the "last mile" connection to public transport (Shaheen et al., 2010).

One of the biggest turning points could be when this bike sharing programs will be integrated with other real-time transport information systems. In fact, nowadays, each one of the aforementioned bike sharing programs has their own website and mobile app.

2.4. ATIS for Multimodal Transport

Currently ATIS are oriented to give information about only one mode. This means that travellers using ATIS are not able to get information to go from point a to b using more than one mode. Therefore, the future tendency is to create a system that provides integrated information for automobile, public transport, cycling and walking.

The approach of multimodal ATIS is to deploy a system that could integrate the following existent information services:

- *Road traffic information:* route, distance, specific route characteristics (road type, one ways, restrictions, road junctions), and dynamic information about current or future traffic conditions. The service is provided as pre-trip and on-trip information to plan a route or to select a destination depending on the current and future traffic conditions;
- *Parking information*: parking facilities and current availability to park;

- *Carpooling information*: option of driving with someone else from their origin to their destination, allowing drivers and passengers to match both trip schedules and personal characteristics;
- *Public transport Information*: real-time information about all PT modes their stops and their routes;
- *Bicycle Information:* real-time information about the bike sharing availability and cycling routes;
- *Walking information*: pedestrian maps, pedestrian points of interest (information for Tourists, opening days and hours, entrance fees).

Multiple and disperse websites cause people to miss useful information or be unaware of the extensive transport options available in the region (Regional Transportation Authority, 2013). Many studies claim a joining of information; for example, thirty percent of Washington commuters would like to see an expansion of the Automated Parking Information System that provides heavy-rail commuters with station parking availability information at en-route roadside locations (T3 Design, 2010).

The Multimodal Trip Planning Systems are envisioned as a planning tool designed to generate integrated travel itineraries enabling users to compare travel itineraries and modes verifying costs and travel times. The ultimate goal is to enable travellers to make smarter travel decisions, increase PT ridership, decreased traffic congestion and improves air quality (Biernbaum et al., 2011).

The multimodal integration is not a recent idea, in 1991, the U.S. Congress passed a bill "Intermodal Surface Transportation Efficiency Act of 1991" emphasizing the fact that effective dissemination of information regarding transport services is essential in promoting a balanced use of different transport modes, which would, in turn, alleviate traffic congestion, reduce energy consumption and air pollution while promoting economic development and supporting the U.S. preeminent position in international commerce. This multimodal view was described by this bill as the centrepiece of the U.S. investment commitment to create the new wealth of this Nation for the 21st century (RITA, 2012).

Under the DRIVE European project, Polak and Jones (1993) studied the effects of pre-trip information on travel behaviour in Birmingham and Athens. Their analysis revealed that there is a real requirement for multimodal travel information even if the travellers usually travel by car. Also Grotenhuis et al. (2007) found that there is a real desire for integrated multimodal travel information.

In this way, some pilot projects have started to use this multimodal perspective. One example is the In Time project (The Intelligent and Efficient Travel Management for European Cities) that started in 2009 by six European cities (Oslo; Munich; Brno; Vienna, Austria; Florence; and

Bucharest) with the intention to provide travellers real-time information. This project is based on a pan-European approach to provide real-time traffic and travel information through an open, standardized services oriented to the infrastructure and business-to-business services. These services will facilitate access to urban traffic and real-time traffic data, enabling travel information service provision and interoperability by traffic information service providers (Böhn and Lamprecht, 2009). This project is still ongoing and its conclusions are not available at the moment that this thesis was written.

Another attempt to apply a multimodal system was develop by the Regional Transportation Authority of Northeast Illinois under the sponsorship of the U.S. Federal Transit Administration named "Goroo". The system was made available to the public in April 2009. The "Goroo" wanted to enable the travellers in the Chicago area to navigate through an extensive network of buses and rail services, toll-ways, expressways and major arteries. The concept of Web-based Multimodal Trip Planning System in the Chicago area is to integrate driving itineraries, PT trip planners, and real-time monitoring systems. The aim is to provide side-by-side comparisons of trip itineraries using PT, car or any combination of non-motorized modes, such as biking and walking. The goal is to create a comprehensive decision support tool for choosing travel options allowing users to get efficiency and low cost (Maccubbin, et al., 2008). Biernbaum et. Al (2011) concluded that:

- Goroo trip-planning website was useful in helping new residents to establish efficient transport habits as they increased their knowledge of the local transport system. Goroo encouraged PT use among users who were undecided on what mode to take or did not intend to take PT at all. Nearly 40 percent of all respondents and 50 percent of suburban respondents reported using at least one PT service that they did not usually use;
- sixty-six percent of the survey respondents indicated that they will visit, on a weekly basis, a site that provides multi-modal trip planning;
- market research reviews during the project indicated that travel time information was important to travellers, but it was not the sole reason for the mode choice;
- a well-designed trip planning website should be more than just an itinerary-trip planner, but should also be able to effectively capture and convey real-world factors, such as fuel prices and congestion information to make PT an increasingly attractive option; and,
- there was an increased desire for information about real-time vehicle location, predictions, and disruption notification, particularly when travellers were en-route and using mobile devices.

On 2009, the routeRank planner was operational: it is an online tool for users to plan efficient travel. Users specify their departure point, destination and time of travel and the routeRANK system combines road, rail and air transport information to return a list of ranked journey options. Users can rank these options in terms of the price, journey time or even the CO_2 emissions associated with the various routes. The results suggest that different user types will vary in the amount they could potentially save. An "average" user for example, could stand to save around 35% of the journey price as well as around 2 1/2 hours in research time (Davidson, 2009).

The analysed literature suggests the urgent need of integrating the information modes because it can influence the traveller perception of the trip context since multimodal information explain and compare travel alternatives and present them in an understandable format. It is believed that these systems will contribute to reduce substantially the complexity of the choice of the travellers, notably in the case where a traveller faces a dense multimodal transportation network (Chorus et al., 2006).

In European cities, there are several operational multimodal systems. In the Table 3 some examples of existing multimodal journey planners are presented.

Table 3 – List of European multimodal journey planners

Country City	Name	Operator	Funding	Commercial	Modes	Website
AUSTRIA	SCOTTY	Austrian Federal Railways	Public	Free of charge	rail, public transport, walking	http://www.oebb.at/
	VERKEHRSPILOT	Austrian Federal Railways, ASFINAG and Austrocontrol	Public	Free of charge	rail, public transport, car, air, walking	http://www.verkehrspilot.at/
BELGIUM	NMBS-SNCB	National Railway Company of Belgium	Public	Free of charge	rail, walking, bicycle	http://www.b-rail.be/
	INFOTEC	TEC – Walloon Public Transport	Public	Free of charge	rail, public transport, walking	http://www.infotec.be/
CZECH REPUBLIC	IDOS	CHAPS Ltd (for Ministry of Transport)	Public	Free of charge	rail, public transport, air, walking	http://jizdnirady.idnes.cz/

DENMARK	BilRejseplanen	Rejseplanen		Free of charge	rail, public transport, ferry, bicycle, car, walking	http://www.rejseplanen.dk/
ESTONIA	Peatus.ee	Estonian Road Administration	Public	Free of charge	rail, public transport, air, ferry	http://www.peatus.ee/
FINLAND	Journey.fi	Finnish Transport Agency	Public	Free of charge	rail, public transport, ferry, walking	http://www.journey.fi/
FRANCE	Multicity Citroën	Citroën	Private	Free of charge	Car, rail, public transport, ferry, air, bicycle, walking	http://www.multicity.citroen.fr/
	Smartmoov' *	Optimod'Lyon Project	Public	Not available	Car, rail, public transport, bicycle, walking	Not available
GERMANY	DELFI (Smartphone app)	DELFI Network		Free of charge	rail, public transport, bicycle, taxi, walking	http://www.delfi.de/
	Reiseauskunft	Deutsche Bahn AG	Public	Free of charge	rail, ferry, public transport, cycling, taxi, walking	http://reiseauskunre.bahn.de/

IRELAND Dublin	Hit the Road	Commutable	Private	Free of charge	rail, public transport, private coach, car, walking	http://hitthroad.ie/
ITALY Torino	SmartWay (Smartphone app)	SmartWay consortium	Private (EU Funding)	Free of charge (Available at Torino and Dresden)	public transport, walking	http://www.smart-way.mobi/
NETHERLANDS	9292	REISinformatiegroep	Private	Free of charge	rail, public transport, ferry, walking	http://9292.nl/
PORTUGAL Lisboa	Transpolis	Transpolis consortium	Public (EU Funding)	Free of charge	rail, public transport, ferry, walking	http://www.transporlis.sapo.pt/
SWEDEN	RESROBOT (Smartphone app)	Samtrafiken		Free of charge	rail, public transport, ferry, car, air, walking	http://reseplanerare.resrobot.se/
	Trafiken	Trafikfrågo		Free of charge	car, bicycle, public transport	http://trafiken.nu
SWITZERLAND	routeRANK	routeRANK	Private (Swiss public funding)		air, train, car	http://www.routerank.com/
UNITED KINGDOM	Transport Direct	consortium, led by Atos	Public funding	Free of charge	rail, public transport, ferry, car, bicycle, walking	http://www.transportdirect.info/

* The mobile application Smartmoov' is the object of this research.

3. Real-Time Information Systems

Cham et al. (2006) analysed the return of investment of real-time bus arrival information systems and made a collection of the theoretical benefits that they could have on the transport systems. They identified the stakeholders and attributed to them qualitative benefits, then related to quantifiable benefits. The authors split the benefits in two groups: Customer-Facing Technology Benefits and Enabling Technology Benefits. A synthesis of their results is reported in the Figure 8.

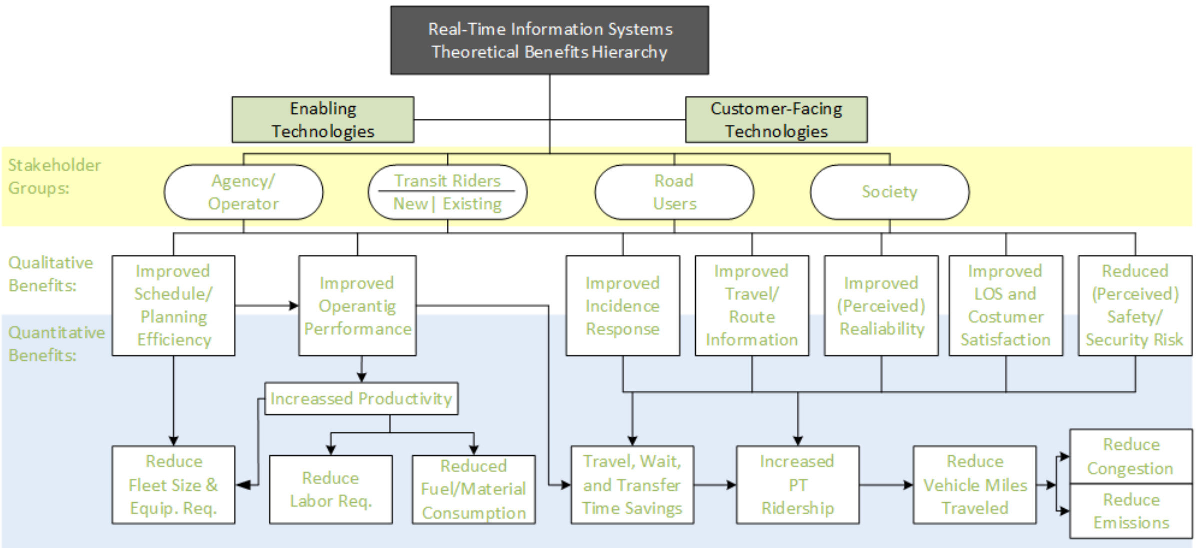


Figure 8 - Real-Time Information Systems Theoretical Benefits Hierarchy
Adaptation from: Cham, et al., 2006

Cham et al. (2006) refer that the major benefits for the Customer-Facing Technology Benefits are:

a) *Improved Travel/Route Information*

Existing or potential PT riders can use real-time information to take better decisions about when to begin their trip, which modes to use, where and how long to commute and the expected duration of the trip. The basic pillar for implementing real-time information systems is the perspective that they might reduce the overall travel time for. Similarly, the availability of vehicle arrival time reduces traveller uncertainty and the related "wait-time anxiety" experienced by passengers waiting for the next vehicle to arrive at their stop. It may also induce new or existing PT riders to select better travel options/services that have lower travel times than they would have originally experienced or expected. This can ultimately result in more frequent and/or new PT trips. Another consequence is that new PT trips can replace private vehicle trips and, consequently, can reduce the operations and maintenance costs of road users by reducing the vehicle miles travelled by private vehicles and related costs. It may also reduce congestion levels on roads, travelling time for road users and environmental impact (i.e., air, noise and water pollution).

b) Improved (actual or perceived) Reliability

PT riders can experience or perceive greater service reliability. Even if a PT rider does not use "pre-trip" information, passengers are more satisfied knowing how long the wait will be for the next bus or when a delay has occurred. Potential PT riders are more likely to consider using the service with improved reliability.

c) Reduced (actual or perceived) Safety/Security Risk

Enabling and customer-facing technologies can at least improve the perceived safety and security of passengers, shifting ridership patterns if not ultimately increasing ridership overall. PT riders may find comfort in knowing that the location of all vehicles is tracked or in knowing how long they will have to wait until the next bus arrives.

d) Improved Level Of Service/Customer Satisfaction

Customer-facing technologies can increase convenience and quality of services and reduce anxiety over delays and other problems. Moreover, customer complaints about poor or lack of service can be better handled with documented evidence of actual performance.

The other group of benefits point out by Cham et al. (2006) was the Enabling Technology Benefits:

a) Improved Schedule/Planning Efficiency

The monitoring capability of enabling technologies together with the analysis of the data allows the agency/operator to make better long-term decisions about service planning. For example, an analysis of data related to operations and maintenance provided by enabling technologies can help improve the accuracy of fleet, labor, equipment and other future requirements. In essence, better matching the planned supply of services with the anticipated demand can reduce service miles and/or service hours. This can ultimately optimize planned capital investments in vehicles, facilities, and equipment.

b) Improved Operating Performance

Enabling technologies may improve short-term productivity by identifying and resolving more quickly short-term problems in operations and maintenance. For example, services that show poor operating performance (e.g. poor schedule adherence due to recurring congestion) can be altered to improve productivity and reduce the fleet, labour, equipment and other material requirements for operations. In essence, enabling technologies can help utilize resources more efficiently by reducing service miles and/or service hours while maintaining the level of service.

In addition, enabling technologies enhance the ability to streamline administrative processes (e.g., billing and payroll) and allow the flexibility of introducing elements of demand-responsive service (such as route deviation) into the regular fixed-route services. With modern technologies, the reservation can be done in much less time or in real-time.

c) Improved Incident Response

Enabling technologies can improve the response to incidents with reliable communication channels and location information between a control centre and the vehicles on the street. The control centre may be able to track the location of all vehicles with a certain level of confidence to determine the impact of an incident or non-recurring congestion on operations. Dispatchers can use this information to devise service interventions or emergency operations in real-time.

Chapter II – Theory of Planned Behaviour

1. Traveller behaviour

When exploring the factors influencing the change of travel behaviour, particular attention has to be given to psychological factors. Therefore, in this chapter, we will explore the human behaviour taking a closer look at the traveller behaviour and at the theoretical models on which the behavioural research is based. At the end of the chapter, some examples of the application of the theory will be analysed.

The expression "Human Behaviour" refers to the actions and mannerisms made by humans in conjunction with their environment, which includes the other systems or organisms around as well as the physical environment. It is the response of the system or organism to various stimuli or inputs, whether internal or external, conscious or subconscious, overt or covert, and voluntary or involuntary. For Ajzen (1991) behaviour can be described as the manifest, observable response in a given situation with respect to a given target. Consequently, the explanation of the complexity of a human behaviour is a difficult task.

The study of human behaviour became an important construct in the psychology in the 20th century, with the advent of the paradigm known subsequently as "behaviourism." In the second half of the 20th century, behaviourism was largely eclipsed as a result of the cognitive revolution and in the 1970s and 1980s emerged the so-called behavioural change theories.

Behavioural change theories and models are attempts to explain the reasons behind alterations in individuals' behavioural patterns. These theories cite environmental, personal, and behavioural characteristics as the major factors in behavioural determination. In recent years, there has been increased interest in the application of these theories in the areas of health, education, criminology, energy and international development with the hope that understanding behavioural change will improve the services offered in these fields.

Each behavioural change theory or model focuses on different factors attempting to explain behavioural change. The most prevalent theories are the learning theories, the Social Cognitive Theory, the Theories of Reasoned Action and Planned Behaviour, the Transtheoretical Model and the Health Action Process Approach.

This research was based on the theory of planned behaviour. This theory has been largely applied to understand the link between intention and behaviour in many fields with positive results, being a powerful and predictive model for explaining human behaviour.

2. Theory of planned behaviour

First described in 1985, the theory of planned behaviour (TPB) is today one of the most popular social-psychological models for the prediction of behaviour (Ajzen and Cote, 2008).

The TPB has been selected because it is a theory designed to predict and explain the human behaviour in specific contexts. Hence, the goal of our investigation is to predict and explain the changes of behaviour in travellers due to the use of new information technologies (Ajzen, 1991). This theory also provides clear definitions of constructs and is supported by a comprehensive body of correlational evidence (Russo et al., 2011).

The TPB assumes that the majority of human behaviours is goal directed, socially influenced and that individuals are logical and rational in their decision-making. It is a deliberative processing model that implies that individuals make behavioural decisions based on careful consideration of available information (Skår and Sniehotta, 2008). In addition, it recognizes the need to estimate the extent to which individuals are capable of exercising control over the behaviour in question.

Ajzen (2012), the founder of the theory of planned behaviour, schematizes his theory using the diagram presented in the Figure 9:

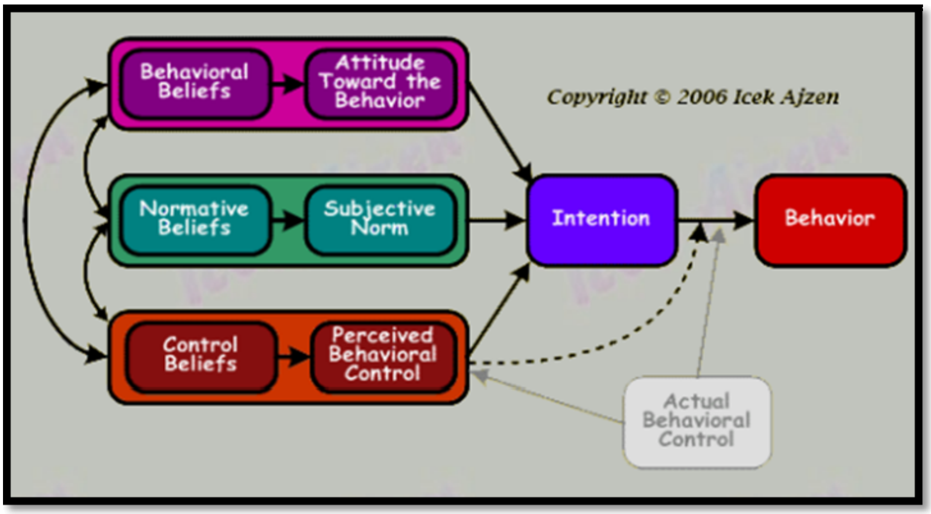


Figure 9 - TPB Diagram

Source: Ajzen, 2012

According to the theory, the human behaviour is guided by three kinds of beliefs (Ajzen, 2013):

- *Behavioural beliefs* – the beliefs about the likely outcomes of the behaviour and the evaluations of these outcomes produce a favourable or unfavourable evaluation of the behaviour, so called *attitude toward the behaviour*;
- *Normative beliefs* – the beliefs about the normative expectations of others and the motivation to comply with these expectations generate a perceived social pressure to perform or not perform the behaviour, named *subjective norm*. In other words,

subjective norms are posited as global perceptions of social pressure that derive from judgments of social pressure from salient others, weighted by the motivation to comply with this group or individuals (Armitage and Conner, 2001);

- *Control beliefs* – the beliefs about the presence of factors that may facilitate or impede the behaviour and the perceived power of these factors give rise to the perceived capability to perform the behaviour, entitled *perceived behaviour control* (PBC). The rationale behind the perceived behaviour control is that it allows the prediction of behaviours that are not under complete volitional control and that provide information about the potential constraints on action as perceived by the actor. Essentially, it explains why intentions do not always predict behaviour (Armitage and Conner, 2001).

Figure 9 shows the combination between the attitude toward the behaviour, the subjective norm and the perceived control that lead to the formation of behavioural intention (Ajzen and Cote, 2008). Intentions are assumed to capture the motivational factors that influence the behaviour and to indicate how hard people are willing to try or how much effort they would exert to perform the behaviour (Ajzen, 1991). As a general rule, the more favourable the attitude and subjective norm are and greater the perceived behaviour control, the stronger should be the person's intention to perform the behaviour in question.

The grey solid arrow pointing from actual control to the intention-behaviour link indicates that volitional control is expected to moderate the intention-behaviour relation so that the effect of intention on behaviour is stronger when actual control is higher rather than low. That perceived behaviour control, when veridical, can serve as a proxy for actual control (dotted arrows in the Figure 9 that connect actual control to perceived control and perceived control to the intention-behaviour link).

Therefore, according to the theory of planned behaviour, human social behaviour is reasonable. Although people's beliefs may be unfounded or biased, their attitudes, subjective norms, and perceptions of behavioural control are assumed to follow reasonably from these beliefs, to produce a corresponding behavioural intention, and ultimately to result in behaviour that is consistent with the overall tenor of the beliefs (Bamberg et al., 2003).

In summary, according to the TPB, volitional human behaviour is immediately preceded by intention to engage in this behaviour. Behavioural intention is predicted, in turn, by three main determinants: attitude towards the behaviour, subjective norm, and perceived behavioural control (Lee et al., 2010).

3. Implementation of TPB

A large number of studies have used the theory of planned behaviour to examine the psychological antecedents of actions in various domains. The scope of this section is to review and analyse previous TPB meta-analysis studies to support the decision of choosing this theory as support of the research.

Ajzen's (1991) meta-analysis of the TPB found an average multiple correlation attitude, subjective norm and PBC, with intention (R = .7; 19 correlations), and an average multiple correlation of (R = .51; 17 correlations) for prediction of behaviour from intention and PBC.

Godin and Kok (1996) indicated in their meta-analysis that TPB performs very well for the explanation of the intention. Also, they showed that half of the studies reviewed that perceived behavioural control significantly contribute to the prediction of intention and behaviour.

Armitage and Conner (2001) analysed 161 articles contained 185 independent empirical tests of the TPB. The result of their analysis is synthetize in Table 4:

Table 4 – Average component relationships for all test of the TPB

RELATIONSHIP	N OF TESTS	R^a	R^2	FAIL-SAFE N	χ^2
MULTIPLE CORRELATION (BI+PBC) WITH BEHAVIOUR	63	.52	.27	65.347	648***
BI–BEHAVIOUR CORRELATION	48	.47	.22	26.235	396***
PBC–BEHAVIOUR CORRELATION	60	.37	.13	27.498	677***
% VARIANCE ADDED BY PBC TO BEHAVIOUR	66	.14	.02	3815	285**
MULTIPLE CORRELATION (ATT+SN+PBC) WITH BI	154	.63	.39	986.974	3231***
ATT–BI CORRELATION	115	.49	.24	326.497	1050***
SN–BI CORRELATION	137	.34	.12	201.774	1167***
PBC–BI CORRELATION	144	.43	.18	378.681	2224***
% VARIANCE ADDED BY PBC TO BI	136	.24	.06	89.753	1086***
BEHAVIOURAL BELIEF–ATT CORRELATION	42	.50	.25	34.201	413***
NORMATIVE BELIEF–SN CORRELATION	34	.50	.25	20.794	451***
CONTROL BELIEF–PBC CORRELATION	18	.52	.27	6174	269***

Notes: ***p<.001; [a]Weighted by sample size; BI=behavioural intention; PBC=perceived behavioural control; ATT=attitude; SN=subjective norm.

Adapt from Armitage and Conner, 2001

The authors conclude that there is evidence supporting the use of TPB for predicting intention and behaviour, since all correlations presented in Table 4 may be classified as representing a "medium" to "large" effect.

Their study found that the average multiple correlation of intention and perceived behaviour control with behaviour is equal to .52, accounting for 27% of the variance (R^2 = . 27), as shown in the Table 4. Furthermore and more importantly, the average multiple correlation of attitude, subjective norm and PBC with intention is R= .63 (R^2=.39). Another conclusion is that, the correlation between subjective norm and intention is significantly weaker than the other relationships with intention.

Sheeran (2002) reported a mean correlation of .53 between intention and behaviour. The author concludes, as well, that the multiple correlations, subjective norm, perceived behaviour control and attitudes, for the prediction of intentions, ranged from .63 to .71.

A large number of studies have used the theory of planned behaviour to examine the psychological antecedents of actions in various domains. Many studies have substantiated the predictive validity of behaviour domains. Here we analyse two case study that support the theory and that will be an empirical support for our investigation.

Case Study 1 - Choice of Travel Mode in the Theory of Planned Behaviour: The Role of Past Behaviour, Habit, and Reasoned Action

Bamberg et al. (2003) wrote an article about a study that investigated the effects of the introduction of a prepaid bus ticket on the use of bus among college students at the University of Giessen in Germany. The study was made using two waves of questionnaires, one before the introduction of the prepaid ticket and one after.

They conclude that attitudes, subjective norms and perceptions of behaviour control accounted for 49% of variance in intentions in the first wave and for 64% in the second wave and, in both waves, intentions had strong and significant paths to report bus choice. These results were consistent with the authors' major hypothesis that the predictors in the theory of planned behaviour are sensitive to new information, even in routine behaviour as in this case study.

In fact, this study found that attitude, subjective norm, and perceived behavioural control influenced students' intentions to take the bus to the campus, and these intentions, in turn, permitted quite accurate prediction of reported behaviour. Introduction of a prepaid semester bus ticket proved to be an effective intervention, more than doubling the proportion of students who rode the bus to the campus, rather than drove their cars. The effects of the intervention on behaviour could be traced to its effects on the antecedent determinants: It raised attitudes, subjective norms and perceptions of behavioural control with respect to using the bus to go to the campus, thus strengthening intentions to do so and, ultimately, affecting reported behaviour.

The results of this study support the point of view that, nevertheless the routine, human social behaviour is always regulated at some level of cognitive effort. Students who had been using their cars were involved in a routine sequence of behaviours that did not require much deliberation, therefore did not have to make their travel-mode decisions every single day. However, the study shows that they reconsidered their opinions after the prepaid semester was introduced. This proofs that the students were monitoring the situation sufficiently to become aware of the new bus plan and to recognize its relevance to their own behaviour. Subsequently, a considerable proportion of students began riding the bus to the campus.

The results of this study demonstrate the utility of the Theory of Planned behaviour as a conceptual framework for predicting travel-mode choices and for understanding the effects of an intervention on the travel behaviour.

Case Study 2 - Theory of Planned Behaviour and Teachers' Decisions Regarding Use of Educational Technology

Lee et al.(2001) studied the use of computers to create and deliver teachers' lessons by using software, such PowerPoint.

The main finding of this study is the demonstration that attitude towards the behaviour, subjective norm and perceived behavioural control served as significant antecedents to teachers' intentions to use computers to create and deliver lessons. They examined the relative strengths among the three factors and found out that the attitude towards the behaviour was two times more important than the subjective norm and three times more relevant than the influence of perceived behavioural control on teachers' intentions to use computers to create and deliver lessons. These findings have suggested that teachers believe that there are positive educational outcomes if using computers to create and deliver lessons. Teachers are less concerned about what others think of this practice and far less bothered by any internal or external constraints that may exist.

This study has both theoretical and practical importance. With regard to the TPB, it refined the application of widely used social psychological theory by reemphasizing the importance of providing specific definitions of the target behaviour.

The above studies demonstrate the utility of the Theory of Planned behaviour for studying decisions regarding the use of technology.

Chapter III – Traveller Decisions under ATIS

Advanced traveller information systems (ATIS) are intended to assist travellers in planning and decision making for mode, departure time, and route choices, including congestion avoidance, to improve the convenience and efficiency of travel. The impact and effectiveness of ATIS, however, critically depend on traveller’s responses to these systems and to the information that they offer. Therefore, it is essential to understand the traveller’s decision making process under real-time information (Abdalla and Abdel-Aty, 2006).

If, and in what way, systems like these have an effect is highly dependent on how they are co-opted by users. Manifestly, this is not only a technological, but also a social process which merits technology assessment (Gotzenbrucker and Kohl, 2011).

It is not easy to define and document ATIS impacts and quantifying ATIS benefits is especially difficult, due to the lack of real-world environments in which travellers’ behaviour, under the influence of ATIS, can be observed (Abdel-Aty, 2002).

However, there have been many attempts to quantitatively and qualitatively evaluate ATIS benefits. The previous studies used mainly three methodologies to assess these benefits, namely surveys, field experiments or simulations and assignment methods (Williams et al., 2008).

Surveys have been the most common methods for ATIS evaluation. Surveys conducted after installing and operating an ATIS are designed to estimate user satisfaction and the effects of ATIS operation (Williams et al., 2008).

Field Experiments are the most accurate and illustrative method to understand the effects of ATIS on travellers' behaviour. ATIS experiments observe the travellers in the real trip environment; therefore, the data recorded in these field experiments are an accurate representation of traveller behaviour because these are real decisions being made in a real environment. These kinds of experiments present two major drawbacks: one is its high costs; the second is that experiments in the transport field tend to require cooperation and coordination among various agencies. The results of an experiment are known either by observing the overall performance or by interviewing the travellers involved (Abdel-Aty, 2002).

Route choice process in the real traffic environment is very complex, therefore several researchers decided use to simulations and assignment methods to analyse route choice behaviour. In this case, the computer simulation programs are the data collection tools. The view is that the level of control of the simulations allows to restrict and analyse adequately the effects of various factors on route choice behaviour.

This section reviews studies conducted to understand the traveller’ choices under the influence of Advanced Traveller Information Systems (ATIS).

1. Users' characteristics and needs

Several ATIS were implemented in the last decades. Several studies have been made to understand the profile of users as well as what they expect from the systems.

Researches on literature found that the socio-economic characteristics of the individuals could be proxies of the actual behavioural factors, affecting the use of information.

Petrella and Lappin (2007) found that users of online traffic information were mainly male, between 26 and 45, highly educated, with a high income and frequent users of information and communication technologies. Meanwhile, Hope and King (2006), in a survey of users of Traveline (ATIS in Scotland), found that users were mainly women, aged 25-44, employed, on a high income, and living in urban areas. Wolinetz et al. (2004) refer that the high propensity for seeking travel information was significantly related to respondents who were female, employed, making long trips, facing unexpected congestion and owning a mobile phone. Grotenhuis, et al. (2007) refer that older people have substantially more need for more information in public transport than younger people, throughout all stages of a journey.

Jou (2001) investigated the impact of pre-trip information on automobile commuters' travel behaviour. Analysis was based on an extensive home based interview survey of commuters in the metropolitan area of Taiwan. The author suggests that younger commuters tend to change decision more than older as regards both departure time and route switching. In addition, male commuters are more likely to switch both departure time and route switching decisions than females.

Vaugh and Reddy (1995) conducted a study based on computer simulation experiments using 100 regular commuters from Sacramento (California region) found that male subjects followed the advice more often than females and that less experience drivers followed the indications often than experienced drivers.

Mahmassani (1997) thanks to laboratory-like experiments, computer simulations and surveys determine that younger commuters tend to switch their departure time decisions, while male commuters tend to switch their route decisions.

Khattak et al., (1993) examined short-term commuter response to unexpected (incident-induced) congestion using data collected through a travel survey. This study found out that drivers were more likely to divert if they lived in the city as opposed to the suburbs, where risk seekers, had a higher stated propensity to divert and were male.

Mahmassani et al., (2003) examined behavioural responses of non-commuters under real-time information during shopping trips, using a web survey. This study indicated that gender, age (greater than 40), level of education (college degree) and high income (greater than $50,000) are not statistically significant to explain either route or destination switching.

In conclusion, socio-economic a profile for the travellers that use ATIS did not emerge neither it is proof that the social-economic factors have influence on the use of ATIS. Nevertheless, the literature suggests that a person who uses an ATIS is more likely to be a young and well-educated person living in urban areas.

The nature of journeys people plan and undertake varies for a number of reasons – the modes used, the distance and duration, the journey purpose, the timing constraints and the predictability and familiarity with the trip. Accordingly to that it is not surprising that the demand for and the use of information are influenced by the travel context.

The analysis of Peirce and Lappin (2004) in line with the findings of Abdel-aty (2001), showed that travellers were more likely to seek out traveller information when making (or planning) trips that had certain characteristics. Namely, rates of information acquisition were markedly higher for:

- trips of very long distance and/or duration;
- trips that took place during the morning or afternoon peak periods;
- trips whose purpose was arrival time-sensitive, such as a trip to work or to the airport.

Bonsall and Joint (1991) presented the results of a survey of drivers equipped with a route guidance system as part of the Berlin LISB (Leit and Information System Berlin) trial. The study showed that the percentage of respondents preferring guidance over information was 76% in unfamiliar areas, whereas for the familiar areas it was only 13%. Attitudes and experiences of LISB users showed that around 23% of the total users "almost always" followed the guidance on familiar journeys, whereas around 62% of the users "almost always" used the guidance when in unfamiliar areas. In the same line Grotenhuis et al. (2007) observed that non-familiar travellers use travel information on pre-trip stage mainly to save search time en-route while travellers who frequently use public transport for work or study purposes need less information.

Harris and Konheim (1995) conducted a telephone survey within a programme to develop a strategy for implementing an Intelligent Transport System (ITS) in the 16-county, New York Metropolitan area. They concluded that nearly all peak-hour travellers in the metropolitan area desire enhanced real-time travel information and are willing to pay for access to such information. However, literature generally states that there is among travellers in general a low or none willingness to pay for information provided through current advanced travel information services (Hato et al., 1999; Khattak et al., 2003; Wolinetz et al., 2004) and for public transport (PT)-information among PT users specifically (Neuherz et al., 2000; Molin et al., 2009; Vance and Balcombe, 1997) as PT users mostly feel they have already paid for information provision by buying their ticket.

More about the willingness to pay, Asakura et al., (2000) found that the lower the service fee is charged, the higher the access rate becomes; thus causing the network's total average travel time to be shortened.

In addition, a survey conducted under the framework of the IN-Time project (2009) refer that is clearly the offered services of this kind of Multimodal Real Time Traffic and Travel Information should be free for its users. This report adds that these services must be as well without obligatory registration.

Kim and Vandebona (2002) designed a survey to investigate drivers' responses to traffic information in Daegu metropolitan city. They found that drivers who are familiar with alternative routes have a high propensity to divert from their normal routes; therefore, the authors, state that traffic information should be provided with alternative route information as well. Finally, the authors mention that the number of stops before arriving to work (variable not considered in previous studies) was a significant variable related to the use of traffic information.

It can be concluded that work-related travel is a prime candidate for ATIS usage, because it typically takes place during peak hours and it is arrival time-sensitive. Also, travels to unfamiliar destinations have a high potential for the use of ATIS. These insights show that a traveller's willingness to search information increase when the trip context is unknown as well as the travel alternatives.

Grotenhuis et al., (2007) studied the effects of integrated multimodal travel information (IMTI) on the three decision making stages: pre-trip planning, en-route and re-routing. They found out that search time and travel time savings turned out to be most needed in the pre-trip stage. En-Route, the most desired IMTI types indicate that catching the right vehicle is most important to the customers; orientation, planning and acquiring information on the remaining trip is less important. Travel time savings seem most important en-route. Re-route, customers mainly need real time IMTI to achieve a timely arrival, especially in order to catch a connecting mode. The most-desired re-route IMTI types are mainly related to travel time savings and affective effort savings. Therefore, the authors conclude "It is remarkable that in all three journey stages, travel time savings are important" (pp. 35).

Reliability, timeliness and coverage of the information provided to users are keys to ATIS use (Fayish and Jovanis, 2004; Hato et al., 1999; Polydoropoulou and Ben-Akiva, 1998;). Furthermore, travellers need customized personal (Adler and Blue, 1998; Khattak et al., 1993) and multimodal information (Kenyon and Lyons, 2003; Polak and Jones, 1993). To induce a greater use of ATIS, travellers ask for user-friendly systems, with accurate information service and good graphical design (Fayish and Jovanis, 2004; Gotzenbrucker and Kohl, 2011).

Frequency of service, number of transfers, seat availability, walking time to the PT stop and fare information are among the significant information that commuters desire (Abdel-Aty, 2001).

Regarding the acceptance of the advice Abdel-Aty et al. (1994) conclude that the majority of the respondents (79.9%) indicated that they would accept ATIS advice, and 40.6% indicated they would prefer to receive information before leaving to get to work (pre-trip).

2. Behavioural changes induced by information

The wide distribution of information to the travellers, through the implementation of ATIS, aims at provoking changes on the travellers' behaviour and optimizing the transport networks. Therefore, several transport researchers study the changes that these systems have on transport related decisions.

Commuters tend to change departure times more frequently than routes and modal diversion would occur only in case of significant delay in the chosen mode (Harris and Konheim, 1995; Vaugh et al., 1995). This is possibly a reflection of a limited route choice set in comparison with a broader set of available departure times (Vaugh et al., 1995).

Abdel-Aty (2001) conducted a computer-aided telephone interview in two metropolitan areas in northern California. The results point out the promising potential of ATIS in increasing the acceptance of PT as a commuting mode. In fact, the 38% of non-PT users stated that they might consider using PT if appropriate information is available. Jou (2001), Tang and Thakuriah (2012) found that there is a strong evidence supporting the hypothesis that the provision of real-time PT information systems leads to PT ridership gains. Using a before-and-after comparison of ridership statistics, several authors found that increases in PT ridership result in routes where real-time information is provided (Body, 2007; Cross, 2003; Lehtonen and Kulmala, 2002; Schweiger, 2003; Rolefson, 2003). Schweiger (2003) alerts that it is problematic to conclude that the observed increase in ridership is a direct result of the ATIS, since many other factors (such as population, gas price, transit fare and employment levels) might also influence PT ridership when and after the transit information systems were being implemented.

A co-modal travel planner, combining both private and public modes of transport, was introduced in Stockholm, Sweden, in 2009. The results of two consecutive surveys to travellers, with a nine months lapse, showed that 9% the travellers (5 individuals) claimed to have increased their use of public transportn as a consequence of their access to the travel planner. Furthermore, only one individual reported to have decreased the number of days per week that travelled by car. None of the respondents of this study expected a further decrease in car usage or an increase in public transport usage given access to the travel planner (Skoglund and Karlsson, 2012).

A London Transport (1998) survey determined that the behaviour change induced by PT information could create revenue up to 17.2 million euros (14.5 million pounds), including 1.5 million euros (1.3£ million) for bus companies, 1.4 million euros (1.2£ million) for underground companies, 1.18 million euros (1£ million) for railway companies, and 13 million euros (11£ million) in societal benefits. However, Williams et al. (2008) alert that "deployment of ATIS options does not result in differences in network performance because travellers do not change their original travel plans even in the presence of traveller information" (pp. 36).

Bunch et al (2011) found that the overall number of people who use traveller information on a daily basis represents a relatively small portion of travellers. The current literature does not provide conclusive evidence regarding whether such information systems can successfully increase the use of soft modes (PT, Bicycles, walk). Even among the existing limited studies, investigating the potential effects of real-time PT information systems in attracting more users, the research results are quite inconclusive. While some of research findings suggest positive effects of traveller's information systems on PT ridership (Abdel-Aty, 2001; Abdel-Aty et al., 1994; Cham et al., 2006) other studies indicate limited impact of such information on PT (Chorus et al., 2006; Holdsworth et al., 2007; Zhang et al., 2008).

Finally, Lappin and Bottom (2001), classified the travellers' decisions induced by ATIS into the two major categories:

1. changes of the trip making context. For example, adjustments to residential and/or employment location decisions, adjustments to daily activity schedules, changes in habitual trip making behaviour, effects on non-travel activities, and trip-related stress or anxiety relief are included in this category;
2. change of the trip making itself. The decision to travel or not, the choice of destination, the choice of departure time, mode and route, the re-routing decision in response to an incident, the driving behaviour, and the choice of parking location are involved in the second category.

In 2011 within the Smart-way project, a questionnaire for the evaluation of the SMART-WAY application was designed to understand the impact that the application might had in the society in general. It was found that acceptance and enthusiasm for SMART-WAY application was very high among test users. But users experience some problems related with technology or data. The experimentation showed that, in the view of the participants, this application was really useful, especially for journeys in parts of the city that were not well known rather than for the daily known home or work journey (Smart-Way, 2012).

3. Major aspects that can influence the effective use of ATIS

The analysis of several articles (Aarts et al., 1997; Ajzen and Cote, 2008; Armitage and Conner, 2001; Bamberg et al., 2003; Chorus et al., 2006) allowed to find out three major aspects that could influence the use of the ATIS: Awareness of ATIS Sources, Past Behaviour and Role of Information.

3.1. The awareness of ATIS sources

When making a trip, the traveller can normally choose among a set of options. There are different combinations of times, routes and modes to bring him from the origin to the destination that travellers considering a set of constraints as the cost and the time. However, travellers are, usually, only aware of a handful of travel options and only consider some of those alternatives when making the choice (Chorus et al., 2006). Furthermore, Aarts et al. (1997) found that where there is a travel habit, often only one alternative is known and considered by the travellers.

Peirce and Lappin (2004) used the Puget Sound Transportation Panel (PSTP), a longitudinal survey of household daily travel patterns to understand the level of awareness of ATIS sources, the personal attitudes towards local travel and advanced technologies and use of traveller information for specific trips. This study emphasizes that one of the main factors limiting the use of traveller information is a lack of awareness of the available sources. The survey shows that a majority of the population is still unfamiliar with many of the Seattle region's information services (Table 5).

Table 5 - Awareness and Use of Seattle-area Traveller Information Offerings in 2003

Information Services	Aware of the service	Have ever used service
PUGET SOUND TRAFFIC WEBSITE	49%	22%
KING COUNTY METRO ONLINE	46%	20%
TRANSITWATCH	24%	5%
TRAFFIC TV	33%	7%
WASHINGTON STATE FERRY WEBSITE	58%	28%
BUS VIEW	12%	2%
MYBUS	11%	1%
TV TRAFFIC REPORTS	97%	63%
RADIO TRAFFIC REPORTS	98%	81%

Source: Peirce and Lappin, 2004

The use of traveller information is fairly uncommon, with travellers seeking information on only 10 percent of their trips and making a change in response to information on less than 1 percent of their trips. In other words, the Seattle-area travellers seem to show relatively little interest in services that provide many potential benefits at little or no direct cost (Peirce and Lappin, 2004). It can be concluded as well that perceptions do not always match reality, but if there is a perception that traffic problems are getting slightly better rather than worse, this can explain the fairly low levels of getting information observed in the PSTP diaries.

The UK Transport Direct service registered in 2006 over 10 million user sessions by the end of its second year of formal operation and yet a national survey revealed correspondingly that only the 6% of the public were aware of the service (Lyons et al., 2008). Figure 10 shows the awareness levels in 2006 for a number of major information services in the UK.

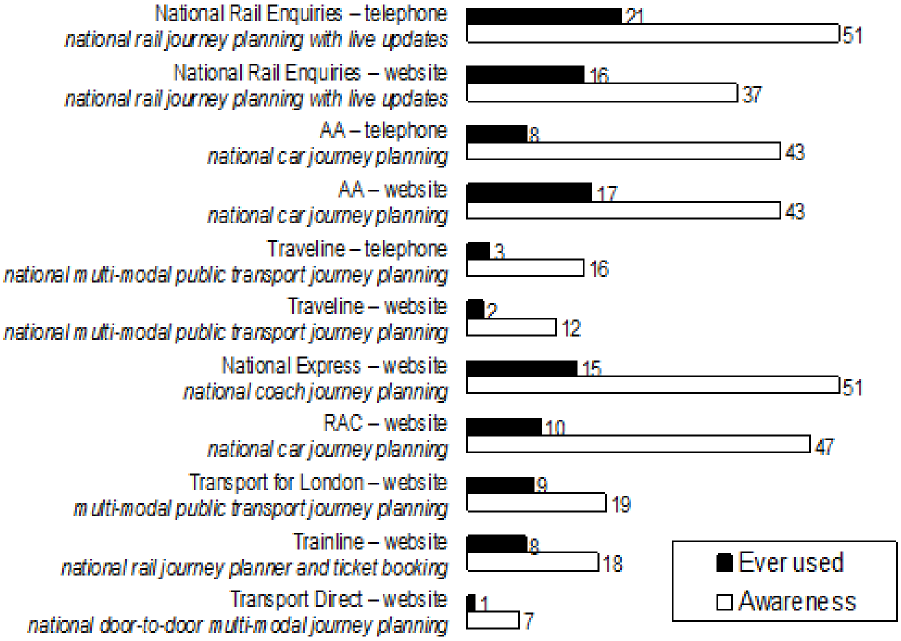


Figure 10 - Awareness and use of travel information services in the UK (% of respondents)

Source: Lyons et al., 2008

The awareness of ATIS for public transport information has been identified as a barrier to modal shift and, definitely, to a more sustainable mobility (Lyons et al., 2008).

3.2. The role of past behaviour

One of the major problems in changing behaviour originates from the role of past behaviour, notably when the behaviour is a routine or even an habit. The travellers have, usually, their preferred route, schedule and mode to get to the destination. Habit is the preclusion of any conscious consideration of choice, because when performing the same behaviour many times, travellers do not weigh pros and cons or check attitudes in order to arrive at a choice (Aarts et al., 1997). Habit may not prevent the use of information altogether since certain confirmatory information may be consulted for example in relation to reliability and uncertainty (Lyons et al., 2008). However, it can be particularly significant in terms of mode choice, limiting the chance that an alternative transport choice is considered. Qualitative research by Kenyon and Lyons (2003) concerning mode choice suggests that individuals have a primary mode which they habitually use for a given journey and a default mode which they revert to in situations where the primary mode is unavailable. Furthermore, they found that "the majority of travels is part of this routine and, as such, the majority of trips are fixed, with the majority of journeys being familiar, made regularly and for a stated purpose". Even during 'leisure time', participants tend to follow an habitual pattern of activities, to decide, for example, when and where to go shopping or to go out in the evenings and how to travel. The authors conclude that "Modal choices are rarely considered for these familiar journeys, having become so habitual that they are performed automatically and without thought" (p. 13).

Gärling and Axhausen (2003) in their overview of the role of habit in travel behaviour do suggest that there remains a question over whether habitual behaviour involves basing decisions on past experiences or whether regular patterns of behaviour are based on using similar information each time and coming to the same decision.

In any case, past behaviour and habits are clearly not always a good predictor of future behaviour. Only when circumstances remain relatively stable prior behaviour makes a significant contribution to the prediction of later action.

3.3. The role of information

Information have a central importance for the decision making process; only well informed commuters can effectively optimize their travel options. Uninformed or misinformed people often do not choose the transport mode that is less time consuming, they cannot bypass incidents' site, waiting for parking and polluting the environment. Beyond detrimental lifestyles, when poorly informed, people fearfully avoid to use other modes of transport, travellers succumb to "irrational routes" and drivers embark on misguided travels.

In this way, it is believed that well-informed citizens are an essential backbone of a free society, and few would dispute the value of more and better information. Yet the possession of accurate information is not a guarantor of wise judgments, nor misinformation is necessarily a precursor of bad decisions. The frequently observed lack of correlation between knowledge and the behaviour producing desired outcomes has led many investigators to conclude that knowledge is a necessary but not a sufficient condition (Ajzen et al., 2011). In transport theory, the travellers base their choices on their perception of, or beliefs regarding, reality instead of the objectively measurable reality itself. For Chorus et al. (2006) "It is obvious that information will not change objective reality, but rather may affect a traveller's perception of this reality" (p 137).

Appropriate or desirable behavioural decisions require accurate information. Abdel-Aty (2002) refers that the factor of utmost importance to any analysis of driver behaviour influenced by ATIS is a measure of the information accuracy. The future success or failure of ATIS will be highly dependent on the accuracy as well as on the quality of advice that can be consistently delivered to the travellers. Additionally, Bonsall (1991) insists on the importance of the compliance with advice; if a system consistently provides bad information, drivers will soon begin to ignore the advice and route choice patterns will remain unchanged. If highly accurate information is consistently provided, drivers will likely perceive a benefit from following the advice and adapt their behaviour to the advice.

Asakura et al. (2000) stated, that providing free information provision allows to reduce the travel time by approximately 20 %, compared to the vehicle with no information at all. Abdalla and Abdel-Aty (2006) show that when the level of information increases (adding en-route to the pre-trip and advice to the advice-free-information) the average travel time decreases. Drivers saved up to 44.7% of the overall travel time when equipped with pre-trip and en-route information with advice as regards to no information. The results showed that drivers who are familiar with traffic information, the network, and the system that provides the information had relatively less delay.

The North Carolina Department of Transportation, the Triangle Transit Authority, the Capital Area Metropolitan Planning Organization and the Durham-Chapel Hill-Carrboro Metropolitan Planning Organization in 2006 introduced in their in their Triangle Travel Survey special questions to learn about the use of traveller information. Through those questions was learned that a strong majority of traveller information users consult the information 5 or more times per week. Furthermore, nearly 80% of traveller information users have altered their travel plans based on this information. In general, the survey also indicated that "higher end" information sources, such as the internet, are more strongly correlated with a propensity to change travel plans (Williams et al., 2008).

Skoglund and Karlsson (2012) alert that co-modal travel planner introduced in Stockholm (Sweden) was trusted, but the perceived value of the service decreased over time being re-used by less than 40% of the respondents.

Information is a key factor in todays' mobility having a high potentiality for maximize the commuter options and ease the travels. However, to properly profit of the information, it is to be provided in an accurate and structured manner and commuters have to be totally engaged.

Chapter IV – Methodology

The objective of this research is to bridge the gap in the existing literature by presenting the results of a research project (Optimod'Lyon), analysing the effects on transport users' behaviour of the real-time multimodal information given by the journey planner Smartmoov'.

The theoretical basis of this dissertation is the theory of planned behaviour (TPB), used to examine the effects of a device (Smartmoov') designed to promote a sustainable mobility, exploring mainly the role of the new advanced transport information systems in the behavioural change.

As previously described through the meta-analysis and some empirical studies, the theory of planned behaviour has been used in several applications in a wide range of domains. However, the research reported in this dissertation is one of the few attempts to use such a theory as a conceptual framework to study the effect of new technologies that might produce a change in travel behaviour. According to the aforementioned theory, it should be possible to influence intentions and behaviour by designing an intervention that has significant effects on three factors: attitudes towards the behaviour, subjective norms and perceptions of behavioural control (Ajzen, 1991).

Still, there is not a well-defined social-economical profile of the users of ATIS, showing that these systems can be used by everyone and that the biggest limitation in their use comes from the lack of awareness of their existence.

People tend to use ATIS during the peak hours, in the unfamiliar and arrival time-sensitive travels, but they are not willing to pay for obtaining this kind of information.

Information is a key factor in today's' mobility, having a high potentiality for optimizing the choice among the commuters' options. However to profit of its potentialities, information has to be provided in an accurate and structured way and the commuters have to be totally engaged in using them. It was understood as well that past behaviour and habits are not always a good predictor of future behaviour.

The literature shows that the complex human behaviour is cognitively regulated and, even after numerous enactments, appears to be subjected to at least some degree of monitoring. As a consequence, the new information given by the Smartmoov' application, if relevant and persuasive, could change behaviour, norms, and control beliefs affecting intentions and perceptions of behavioural control and being able to influence later behaviour in the higher end.

1. Research context and objectives

In the previous chapters the reported researches show that ATIS are a key element to answer to the challenge to accommodate the increasing demand for road transport while reducing road fatalities, congestion and environmental impacts and that these systems will encourage travellers to make best use of the available transport modes and to support an integrated and sustainable transport system.

In response to this list of ATIS benefits, for individuals and transport systems, many cities and countries have invested in and deployed these systems. Although transport agency experience and customer satisfaction with ATIS deployments have generally been positive, methodologies for quantifying the real benefits and changes to the network are lagging behind.

Indeed the broad research question of this study is to describe the impact on mobility of the introduction of a Smartphone app (Smartmoov'), providing real-time information. Thus, the aim of this research is to measure the impacts of ATIS, and notably of Smartmoov', on travel behaviour.

This research has been carried out within the context of the Optimod'Lyon project., a 3-years project developed through a partnership among Grand Lyon, industries and research laboratories to answer to the call for projects on urban mobility launched by ADEME (French Environment and Energy Management Agency), within the framework of "Investissements d'avenir" programme run by the French government. This project aims at favouring a more sustainable mobility,

The Optimod'Lyon is a pioneering and innovative project in terms of technology and governance, with a global budget of 7 million €, funded by ADEME.

The objective of facilitating the travels of individuals, improving the environmental conditions in the city and promoting the development of the know-how of local and national enterprises, has pursued developing three major services: one hour traffic prediction; a multimodal real-time urban navigator on Smartphone; a navigator for urban freight optimising the delivery routes in the city.

The data used in this research are related to the urban navigator on Smartphone, called Smatmoov'. This app was created to have, at any time, real time and all-mode information to optimise the travels, facilitating the use of transport modes and services for organising the journey, benefiting of all GPS functionalities.

The real time multimodal tool has been implemented to collect data about the travellers' behaviour before, during and after the five months of experimentation of this app. Throughout the five months of experimentation of Smartmoov' three updates were released without significantly changing its *modus operandi*.

In Figure 11, the main screen of the app is presented and it is possible to see that the main features are: choice of the route, list of interest points nearby, public transport schedules, traffic on the route, parking availability, perturbations on the road and bike sharing availability.

Figure 11 - Smartmoov' main screen

One of the major innovations of this app is the real time and all-modes information. The Figure 12 depicts a sample of the feature of the route ("trajet"). First, the user has to define the modes who can effectively use. Then (s)he digits the departure and the arrival addresses and the app gives several options how to reach the destination using all the available modes. In this example, the output shows two different options: one using the car (with information where to park) and, then, taking the train; the second option suggests to use the bus and commuting to the train.

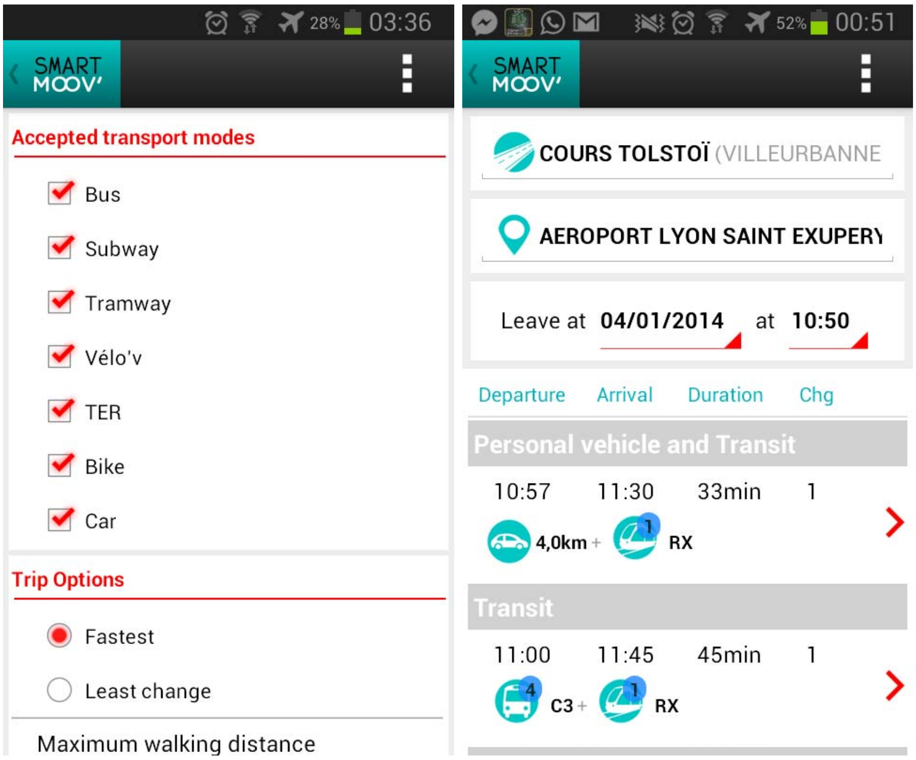


Figure 12 – Feature of the route presented in Smartmoov'

The innovation of this dissertation is the continuous monitoring of people, allowing to have complete information in different time periods and to understand the real impact that the introduction of ITS technology has on traveller behaviour.

As the data were collected mainly in two different periods, before and after the experimentation of Smartmoov', it was decided to segment the analysis in two steps:

- the first study is a contextual and quantitative research which evaluates the attitudes and behaviours of 50 persons before the experimentation of Smartmoov';
- the second study, quasi-experimental analysis using qualitative and quantitative measures repeated in pre-test and post-test (and subsequent follow-up), was related to 46 persons to understand the impact on mobility produced by the introduction of ATIS and the reasons for the measured effects.

Figure 13 presents the framework of the research, whose results will be reported in chapter V.

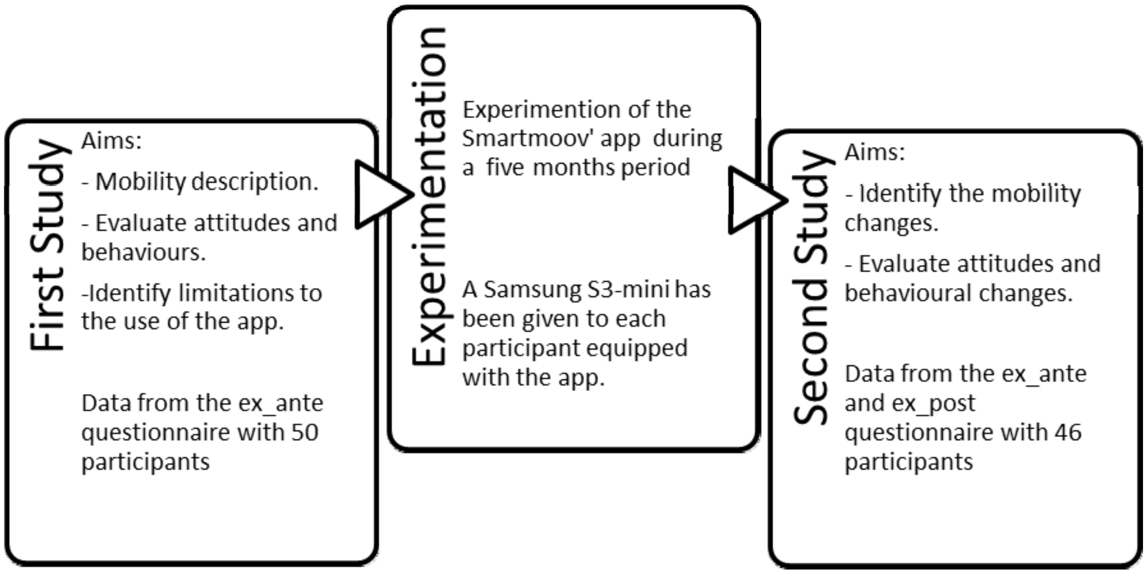


Figure 13 – Framework of the research

2. Design of the survey

Two questionnaires were designed to gather the data, one before and one after the experimentation. As the questionnaires wanted to depict a complex and multidimensional situation, they were quite long. Thus, to mitigate the problems related to the fatigue in answering to the questionnaires, they were divided into four different sections so that the respondents could answer in different periods during the month of February (before the experimentation) and of October 2013 (after the experimentation). In Table 6 a general scheme of the sections contained in the two questionnaires and the sample size is presented.

Table 6 – Sections of the questionnaires

	Sections	**Respondents**
Ex_ante	Personal mobility habits	50
questionnaire	Personal Attitudes related to mobility	50
Before	Familiarity and interest for technological tools	50
experimentation	The application Smartmoov' and personal data	50
Ex_post	Personal mobility habits	46
questionnaire	Personal Attitudes related with mobility	46
After	Familiarity and interest for technological tools	46
experimentation	The application Smartmoov' and personal data	46

The ex_ante questionnaire, completed before the five months of experimentation, aimed at understanding the participants' mobility and the dynamics that could influence the use of the Smartmoov' app.

The main goal of the ex_post questionnaire was to understand the potential changes that Smartmoov' introduction could induce in the participants' travel behaviour.

These questionnaires were available to the participants at google drive platform to be self-compiled. The main advantage of self-compilation is that respondents can be encouraged to admit beliefs and behaviours that are not socially desirable. The downside of this method is that it adds somewhat to respondents' burden and require respondents to have an appropriate level of literacy (Francis et al., 2004).

Both closed and open-ended questions were designed to be understandable and retrievable, avoiding to request calculations by the users. Schwartz et al. (1985) found out that responses on scales affect reporting behaviours. The literature shows that a scale with fewer points generate a lost of information and may fail to discriminate between respondents with different underlying judgments; on the other side, a scale with many points tend to produce cognitive overload and the respondents may fail to reliably distinguish between adjacent categories (Groves et al., 2004). The Likert scale allows symmetry and the attributes are equidistant among them; in this way the variables are in the interval form (Grace-Martin, 2008). For these reasons, we chose to use a 5-points Linkert scale, because it represents a good compromise in terms of overload for the respondent. To avoid reporting errors the same scale was used throughout all questionnaires (Wholey et al. 2004).

Furthermore, it was avoided to ask questions with negative statements and with a negative scale. Verbal labelling scale was used, when possible, because it increases the reliability and validity of the questionnaires (d'Ardenne et al., 2011).

Issues such as validity and consistency of the questionnaires were taken into account, namely content validity and construct validity. To such extent, a literature review supported any choice in the data analysis. In addition, analysis of several studies (Cestac, 2009; Ajzen, 2010; Pronello and Camusso, 2011) allowed to assess the adequacy of the dimensions to be included in the questionnaires. As far as context analysis is concerned, a pre-questionnaire was administered to few people involved in the project in order to check the clarity and adequacy of the items. The aim was not only to time the minutes to fill in the questionnaires, but also to record the difficulties and doubts arising from its administration. The purpose was also to understand the feelings and reactions of the participants to the questionnaires (difficult questions, language issues, more and less valued questions, questions that might hinder participant's responses, and so on). The questionnaires were refined according to the outcomes of this test and the final version was administered to the participants.

The project provided as well two series of focus groups, six before and six after the experimentation. Focus groups are a form of qualitative research in which a group of people were convened around a table to discuss and analyse their perceptions, opinions, problems, beliefs and attitudes towards the multimodal navigator. Questions were asked within an interactive group where participants were free to interact with the other members of the group. The focus group approach was well suited to the objectives, allowed to contain the costs, working with a small group of people; however, it went in depth of the qualitative aspects of the analysed problem (Morgan and Krueger, 1993). These qualitative data are not object of the present dissertation, even though the results of the focus groups were looked at during the quantitative analysis, to cross-check the results got from the questionnaires.

2.1. First Study: Before experimentation

The theoretical framework of the quantitative empirical study about the perceptions before using Smartmoov' app is referred to chapter III, that envisions the theoretical benefits that ATIS can generate on mobility and that highlights that this is not only a technological challenge, but a social process. In fact, this matter urges for a serious assessment because if these systems are designed to have an effect on mobility they will be highly dependent on how they are perceived and used by the people.

This first study was based on the data collected in the initial stage of the research project "Optimod'Lyon", before the experimentation of the urban navigator for smartphone (Smartmoov'). This study is a contextual and quantitative research, which evaluates the attitudes, the behaviours and the technological familiarity of the 50 participants before the use of the application.

With this investigation, we want to understand the variables that could hamper the use the app and in what manner a modal change could happen thanks to the Smartmoov' use.

This study has four major goals further divided into specific objectives:

1. characterize the participants in terms of mobility habits:
   - characterize the participant's mobility (most frequently transport mode used trip duration, scope of the travel, trip frequency and detours);
   - understand the participants' reasons for choosing the transport mode;
2. verify if there are differences between people who use different modes:
   - check if there are different reasons why participants chose a certain mode;
   - discover different personal attitudes related to the transport mode used;
3. understand the perceptions before the use of the Smartmoov' app:
   - describe the habits of participant about the use of technology;
   - identify participant's perceptions about the environment;
   - identify the influence of the real-time information on the ridership of different modes;

- identify the availability of the participants to use the application and their perspectives regarding its usability;
- identify the willingness to pay for using the app;
- evaluate the availability of participants to change their pattern of mobility;
- check the importance (influence) of time as well as of social and environmental factors on the use of the application;

4. behavioural constructs towards the modal shift:
   - identify the influence that different behaviour constructs have on the intention to change travel behaviour.

2.1.1. Design and administration of the ex-ante survey

To understand the viewpoints of the participants before the use of the Smartmoov' App a questionnaire was designed and built using the google drive platform; it was formed by four sections: Personal mobility habits, Personal Attitudes related to mobility, Familiarity and interest for technological tools and Smartmoov' application. The questionnaire was administered to the 50 participants sending to them an e-mail with the link where they found the on line questionnaire who was self-compiled during the month of February 2013.

Section 1 – Personal mobility habits

This section focused on the most frequent trip of the participants, the use of the available modes, the differences of mobility between the seasons and the reasons for choosing the mode of transport. This section presented 53 questions divided into 5 major themes.

The first group, the general mobility habits, contained seven questions: three open questions (home and destination address and time) and four questions where participant's had to indicatethe frequency of the most frequent trip, the scope of the trip, the mode more often used during the Autumn/Winter and Spring/Summer periods.

The second group included six questions, one question to identify if the participants did detours (Yes/No) and five where they had to choose the frequency of the following detours: taking kids to school, shopping, leisure, promenade, meet people.

The third group concerned the mobility habits on the weekdays through 16 questions, eight for each period of the year (Autumn/Winter and Spring/Summer). The answers were distributed on a scale going from 1 ("never or rarely") to 5 ("4 or more often in a week") to assess the use of each type of mode (Car, Moto, PT, TER, Bicycle, Velo'v, Trottinette and Foot).

The fourth group regarded the mobility habits on the weekends providing eight questions distributed on a scale going from 1 ("never or rarely") to 5 ("4 times in a month") to assess the use of each type of transport (Car, Moto, PT, TER, Bicycle, Velo'v, Trottinette and Foot) during the weekend.

The last group of questions was devoted to analyse the reasons of the modal choice. This section contained 16 statements on a Likert-scale from 1 ("totally disagree") to 5 ("totally agree"). Therefore, the participants had to choose, from a list of reasons, which ones were important and which ones were not.

Section 2 – Personal Attitudes related to mobility

This section focused on statements about preferences and attitudes related to the different modes of transport. Furthermore, this section of the questionnaire aimed at evaluating the environmental attitudes of the participants and at assessing the perceived effect on travel behaviour of the real time information. This section included 39 questions on a 5 point Likert-scale ranging from 1 ("totally disagree") to 5 ("totally agree").

Section 3 – Familiarity and interest for the technological tools

This section was totally devoted to understand the skills of participants towards the diverse technological tools that can provide traveller information systems. In total, the 39 questions were divided on four major themes:

- a block of 8 questions was devoted to record the ownership of technological tools: computer, tablet, e-book, smartphone, MP3 and car navigator;
- a block of 8 questions was focused to ask to the participants to self-assess their technological skills towards the aforementioned tools (computer, tablet, e-book, smartphone, MP3, car navigator) on a 5 points Likert-scale ranging from 1 ("Non-user") to 5 ("Expert user"). At the end, an open question allowed the participants to mention other possible tools;
- a block of 8 closed questions was devoted to ask to the participants where they normally get travel information. The questions were designed on a 5 points Likert-scale ranging from 1 ("totally disagree") to 5 ("totally agree"). There was an open question at the end where the participants could point out other technology used for this purpose;
- the final block contained 15 questions aimed at understanding the participants' interests for technology. The questions were asked on a 5 points Likert-scale ranging from 1 ("totally disagree") to 5 ("totally agree").

Section 4 - Smartmoov' application

This last section was focused to the Smartmoov' application and included 29 statements, divided in two major blocks:

- general considerations about the use of Smartmoov', the willingness to pay for it and the reasons for using it. These questions were designed on a 5 points Likert-scale ranging from 1 ("totally disagree") to 5 ("totally agree");
- the willingness to pay depending on the time saved using the app.

2.2. Second Study: Effects of the Smartmoov' use

In the first study, the main issues that could influence the use of the Smartmoov' app were considered. In addition, the mobility patterns of the participants before the introduction of Smartmoov' were asked for. The main goals of this second study are to understand the mobility patterns after the experimentation of Smartmoov', analysing the potential behavioural changes.

This quasi-experimental study provides a description of the participants who answered the ex_ante and ex_post questionnaires with special emphasis to their mobility, behavioural changes and their evolution along the experimentation of Smatmoov'.

This study has two major goals, further divided into specific objectives:

1. the analysis of the changes produced by the experimentation:
    a. comparison between the expected and actual outcomes;
    b. traveller intentions;
    c. effects on travel behaviour;
    d. Smartmoov' Use;
    e. willingness to pay to use Smartmoov';
2. analysis of the behavioural constructs after the experimentation:
    a. investigation of the role of the TPB construction in the traveller behaviour;
    b. understanding the role of intentions as regards modal diversion.

2.2.1. Design and administration of the ex-post survey

To evaluate the effects of Smartmoov' App on mobility a second self-administrated online questionnaire was designed after the experimentation and administrated to the 46 participants in the month of October 2013, after the five months of experimentation. The questionnaire was built using the google drive platform, as the ex_ante questionnaire, and it is symmetric to that to monitor the possible changes: Personal mobility habits, Personal Attitudes related to mobility, Familiarity and interest for technological tools and Smartmoov' application. The questions asked were the same with the only difference that they were related now to the real behaviour after the experimentation, compared to the expected behaviour before the experimentation investigated on the first study.

2.3. The sample selection and the administration of the survey

The 50 participants were "transport users living in the metropolitan area of Lyon" and were stratified by:

- gender;
- age: classes related to people having different technological skills;
- profession/educatiol and income level;
- presence of children under 14 years old in the household;

- mode of transport used to travel: motorized, public transport (PT), soft modes, intermodal (motorized + PT);
- residential location: city centre, suburbs, extra-urban locations, considering also the geographical position (north, east, south, and west). It is important to get the origins and destinations to better choose the people profile also in terms of their residential location;
- physical disability to take into account the difficult to travel (2 people).

Fifty participants answered to the ex_ante questionnaire. However, during the experimental period, four participants left the project and only 46 persons answered to the ex_post questionnaire. Therefore, having as goal to analyse the differences induced by the use of Smartmoov', only the 46 participants who completed both questionnaires were analysed. The collection of the data was made using the google Drive form, a web-based software devoted to administer on-line surveys.

After the data collection of the ex_ante questionnaire, the four sections were aggregated in only one database, using the email address asked at the end of each section of the questionniare. The same procedure was taken for the four sections of the ex_post survey. Later on, the ex_ante and the ex_post questionnaires were aggregated, again using the email addresses.

2.4. Data Analysis Design

The statistical analysis followed a twofold approach: an analysis on each variable and another analysis that studied the relations among the variables. The Figure 14 depicts the scheme of the analysis.

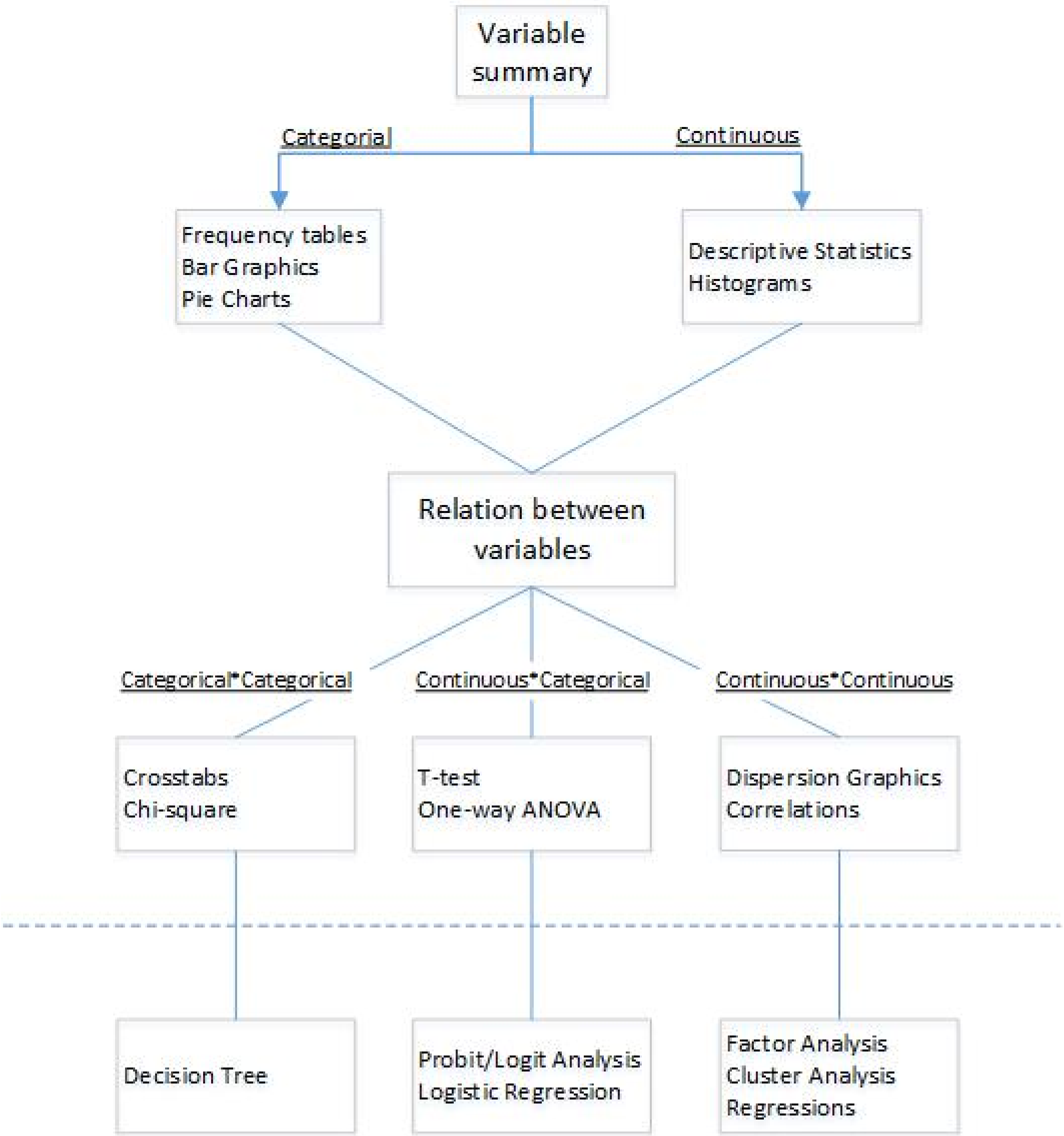


Figure 14 – Scheme of the data analysis

Firstly, to understand and summarize the variables, and depending on the type of the variables, different techniques were used: pie and bars charts and frequency tables were carried out for the categorical variables. Descriptive analysis (e.g. mean, standard deviation) was used for the continuous variables. After this first overview, some questions come out that required further investigation, using different statistical techniques.

Therefore, to understand the relations among the variables, diverse statistical instruments were used, depending on the type of variable. Three subgroups of analysis were carried out:

- Categorical*Categorical: when the two variables were both categorical, we analysed the chi-square and interpret the contingency tables. Since our database has only 50 participants we followed the conventional rule of thumb that if all of the expected numbers are greater than 5, it is acceptable to use the chi-square (McDonald, 2009);
- Continuous*Categorical: to observe the relations between categorical and continuous variables, two strategies were adopted: the use of the t-test and the one-way ANOVA;

- Continuous*Continuous: to assess the relations between the continuous variables two techniques were used, the correlations and the analysis of the dispersion graphs.

To perform the analysis the BMDP, R, SPSS, Winsteps or Factor software were used, depending on the analysis available in the software package.

One main issue related to the use of the statistical tests was the dimension of the total number of participants. Since the total number of participants was small (<50) was not possible to use the central limit theorem neither the Shapiro-Wilk test to guarantee the normal distribution of the variables. We assumed that our data would never be exactly normally distributed and so, following Brown (2011) and Fife-Schaw (2013), we consider the variables relatively normal if Skewness and Kurtosis values range from -1.5 and +1.5 and if z-score is lower than absolute value of 1.96. The z-score were calculated using the equations [1] and [2]:

$$Z_{Skew} = {}^{Skew}/_{SE_{Skew}} \qquad [1]$$

$$Z_{Kurtosis} = {}^{Kurtosis}/_{SE_{Kurtosis}} \qquad [2]$$

As regards the T-test for independent samples we tried to found out if there were significant differences between the users of pollutant and sustainable modes; the null hypothesis was that the mean values related to the pollutant and sustainable users were similar and the alternative hypothesis was that they were significantly different. The results presented in the Chapter V report the variables showing a significant different mean and respecting the null hypothesis that can be rejected, because the t-value is significant. In some cases, the Levene's test for equality of variances was significant, therefore it is not possible to verify the homogeneity of the variances (equal variances not assumed), but still the t-test presents significant values.

In the case that the variables did not meet the normality assumptions, non-parametric tests were used as well as two independent tests, the Mann-Whitney (U) and the Wilcoxon (W) tests.

To investigate the changes before and after the five months of experimentation, parametric test (if the normality assumption was matched) and nonparametric tests (if the distribution was not normal) were used. Nevertheless, where possible, both the parametric test and the more appropriate non-parametric equivalent were conducted. If they arrive at the same conclusion about the null hypothesis, a high accuracy of the results is guaranteed. The parametric test used was the paired t-test while the nonparametric test was the Wilcoxon Signed Ranks (Z).

In addition, one new variable was created with the goal of aggregating the different transport modes into two major groups, the sustainable and the pollutant modes (Table 7).

Table 7 – Transport mode classification

Sustainable mode	Pollutant mode
Public transport	Car
Bicycle	Motorcycles
Walking	
PT+ Soft modes	
PT+car	

The above classification allow to create a binomial variable allowing the use of statistical techniques such as T-test for independent samples and probit/logit analysis.

As already mentioned throughout the questionnaires, a 5-points Likert-scale was used. Consequently, the following assumptions were made: results lower than 2.5 correspond to the "disagree part" of the scale; results between 2.5 and 3.5 are neutral and results bigger than 3.5 are considered on the "agree part" of the scale. When it is stated "agree", the 4 and 5 are included; in the opposite side, when it is stated "disagree", the values 2 and 1 are considered. The Figure 15 graphically reports the above assumptions.

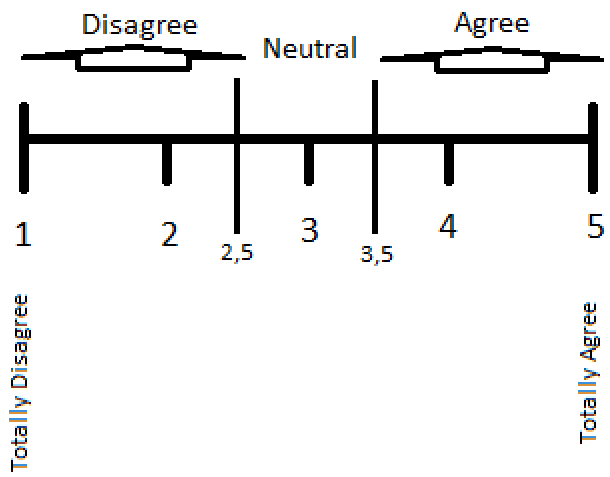


Figure 15 – 5-point Likert scale results

Binary logistic regression is a form of multiple regression which is applied when the dependent variable is dichotomous, that is, has only two different possible values [3].

$$Y_i = \begin{cases} 1 & \text{if the trait is present in observation i} \\ 0 & \text{if the trait is NOT present in observation i.} \end{cases} \quad [3]$$

For a logistic regression, the predicted dependent variable is a function of the probability that a particular subject will be in one of the categories. A set of predictors (X_i) is identified; it assesses the most likely of the two nominal categories in which a particular case falls into. Logistic regression is often chosen if the predictor variables are a mix of continuous and categorical variables and/or if they are not nicely distributed; logistic regression does not make any assumptions about the distributions of the predictor variables (Rodriguez, 2007). The binary logistic regression creates model described by the equations [4] and [5]:

$$\pi_i = \Pr(Y_i = 0|X_i) = \frac{e^{\beta_0 + \beta_1 X_i}}{1+e^{\beta_0 + \beta_1 X_i}} \qquad [4]$$

$$\mathrm{Logit}(\pi_i) = \log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_0 + \beta_1 X_i \qquad [5]$$

Where the probability of the event is coded with zero, π_i is equal to an equation with one constant (β_0) and one predicting variable (X_1) multiplied by the coefficient calculated for that variable (β_1).

The BMDP software predicts the probability of the event that is coded with the smaller number. This procedure estimates the follow parameters:

- $\exp(\beta_0)$ = the odds that the characteristic is present in an observation i when $X_i = 0$;
- $\exp(\beta_1)$ = for every unit increase in X_i, the odds that the characteristic is present is multiplied by $\exp(\beta_1)$. This is an estimated odds ratio [6].

$$\frac{e^{\beta_0 + \beta_1 (X_i + 1)}}{1+e^{\beta_0 + \beta_1 X_i}} = \exp(\beta 1) \qquad [6]$$

The logistic model states that the effect of a covariate on the chance of "success" is linear on the log-odds scale, or multiplicative on the odds scale, therefore:

- if $\beta j > 0$, then $\exp(\beta j) > 1$, and the odds increase;
- if $\beta j < 0$, then $\exp(\beta j) < 1$, and the odds decrease.

In this research, binary logistical regression was used with the intention of predicting the use of pollutant or sustainable modes and to predict the intention to change or maintain the travel habits. Firstly, the forward stepwise method was used; it starts with a model that does not include any of the predictors and, at each step. It addd the predictor with the largest score and with significance value smaller than a specified value (>.05). Afterwards. the results were checked with the backward stepwise method. This method starts with a model including all of the predictors and, at each step, the predictor contributing the least is removed from the model, until all of the predictors in the model are significant *(p* < .05). If the two methods choose the same variables, the model found is a good model.

2.5. Ethical Aspects and Limitations of the Study

The research was carried out within the project Optimod'Lyon and was approved by the DIST - Interuniversity Department of Regional and Urban Studies and Planning of the Politecnico di Torino. All the participants signed a contract informing about the purpose of the study, assuring anonymity and confidentiality and communicating that they could stop participating at any time with no consequences for them.

The design of this research took into account the different aspects that can contribute to affect the internal and external validity of the studies. Although we have attempted to control the factors that could be a limitation to this research, it should be emphasized that the generalization of the results should be carefully made. This is due mainly to the small sample size of the participants of this investigation and to a lack of a control group. These facts have also conditioned the statistical methodology adopted.

Despite the above limitations, we consider that the study can give a valid and pertinent contribution to the knowledge of the subject studied and may be constituted as a critical study on how ATIS influence a transport modal shift.

Having discussed the general considerations concerning the methodology, the next chapter will focus on the results of the two studies.

Chapter V – Results

This chapter is devoted to the presentation of the results of the studies 1 and 2.

Firstly, the results of the first study investigating the participants mobility habits, perceptions, attitudes, technological familiarity before the experimentation of the Smartmoov' are reported. At the end of this sub-chapter, the results of the application of the theory of planned behaviour are presented. As referred on the methodology, this first study had the participation of 50 persons.

Afterwards, the results of the second study are presented. The study analyses the effects produced on the mobility, the attitudes and the perceptions after the experimentation by comparing the answers given to the two-wave questionnaires. The sample is composed by 46 persons being limited by the number of respondents to the second survey.

1. Results of Study 1 – Before using Smartmoov'

The results presented in this section are based on the first analysis carried out to study the normality of each variable. The details can be read in the appendix I.

Sample description

This study involved 50 persons living in the Lyon metropolitan area who completed all the online questionnaires before the experimentation of Smartmoov'.

The present sample presents a perfect balance between genders, 25 males and 25 females. The ages range from 23 to 68 year-old, similar distributed between both genders (Figure 16). The participants mean age is 42.44 years-old.

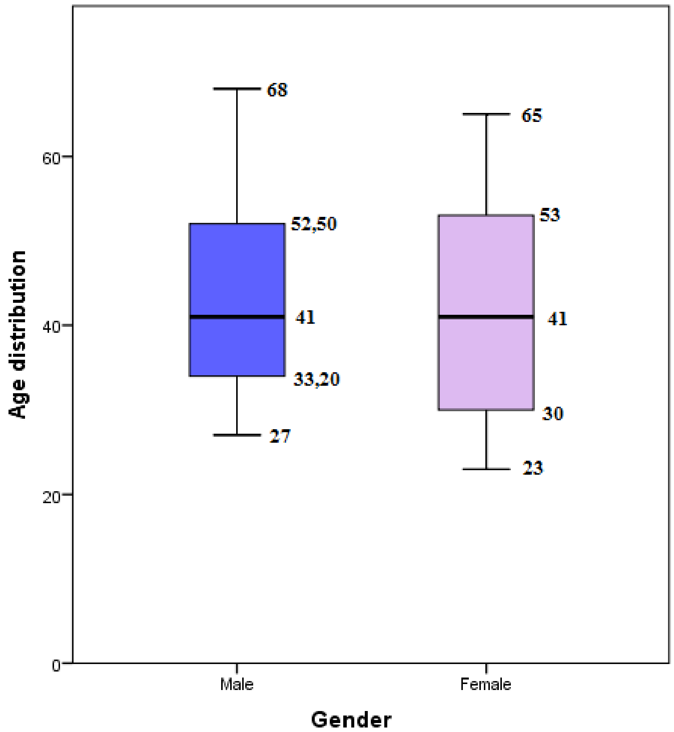


Figure 16 – Age distribution by gender

Figure 17 shows that 16 respondents have a high educational level (1 "Bac+3", 14 "Bac +4 et plus" and 1 "master bac+5"). On the other hand, 34 respondents have not attended the university and two of them do not have any diploma.

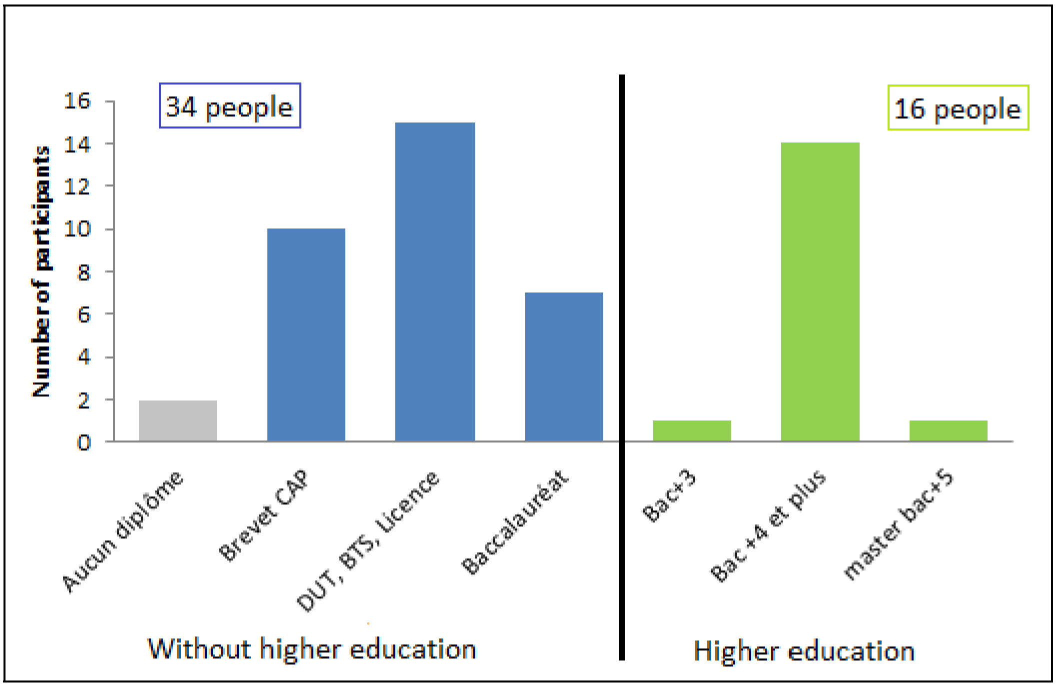


Figure 17 - Education

The household size of the respondents' presents the following distribution: 11 live alone, 19 live with one other person, 7 live with more two people and 13 with 3 or more people. As expected, the number of children in the household shows a significant positive correlation with the household size (r = 0,848, $p < .001$). There are 28 households without children and 22 have children (8 with one kid, 11 with 2 kids, 2 with 3 kids and 1 with 4 kids). The age of the children varies from 2 to 19 years-old. The youngest child is 8 years-old.

Only five respondents do not have a driving license. 45 participants have a car available in the household (22 households with one car; 21 with 2 cars; and 2 with 3 or more cars). Only five of the households do not own a car. There is no significant relation between household size and the number of available cars.

The number of participants who own a PT pass is 17: 7 get an annual pass, 9 a monthly pass and 1 owns a special pass being a disable person. Only three people have the Velo'v pass.

About the wages, only 4 people gain less of 1500 euro/month; 24 have a salary between between 1500-3000 euro/month; 17 between 3000-5000 euro/month; and only 1 person more than 5000 euro/month.

1.1. Participant's mobility habits

Most frequent travel

The distance travelled by the participants for their most frequent trip varies from 170 meters to 56.30 kilometres, taking between 5 and 90 minutes. The variables time and distance show a significant positive correlation (r = 0,689, $p < .001$).

Figure 18 shows that the majority of the people do this travel every working day (five or more days on a normal week).

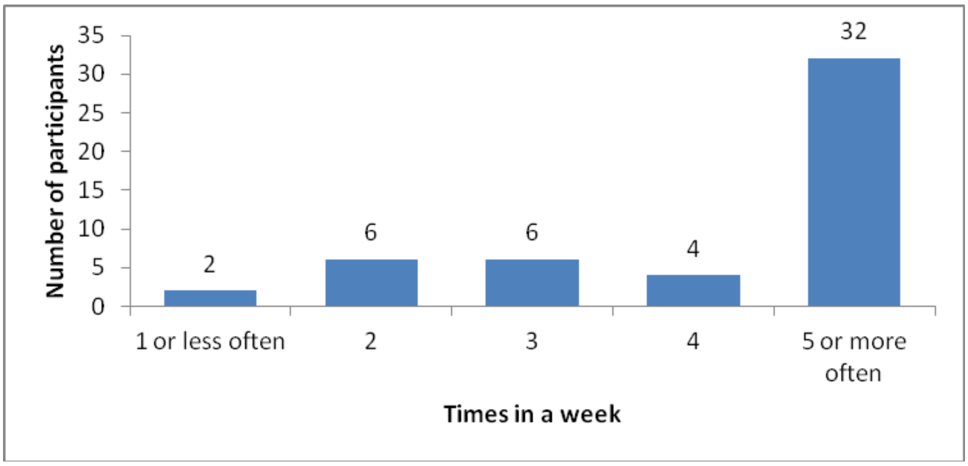


Figure 18 – Many times on the week do the most frequent travel

The purpose of the trip is normally related to travel from home to work 37 participants. Except for 5 participants who travel for leisure and 4 to pick up somebody (Figure 19).

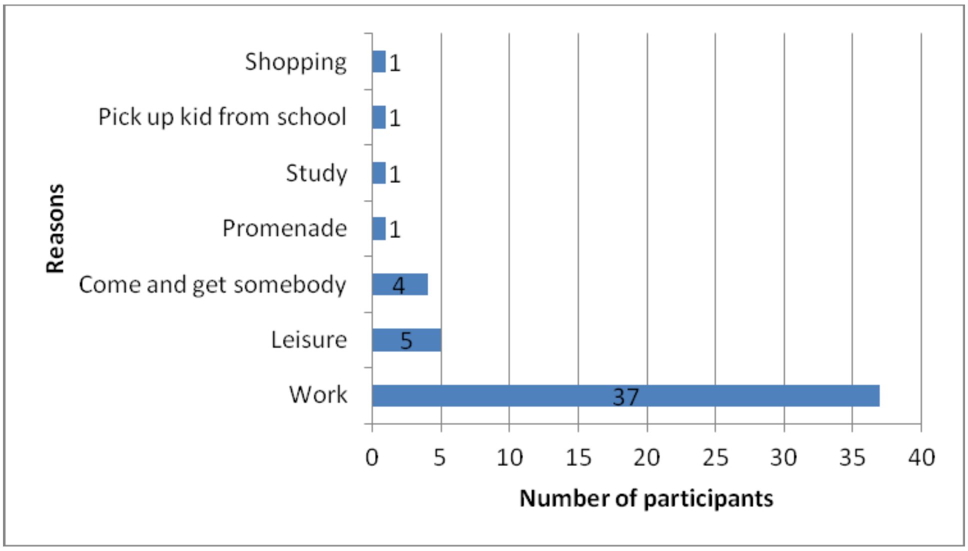


Figure 19 - Most frequent travel motive

The activity taking shorter travel time is carrying the kids to school, taking only 5 minutes (but only one person have this most frequent trip). In general, it seems that travelling to get to leisure activities (37 min) consumed more time than to get to work (32.1 min) and these two take much more than the trips to get or drop someone (18.1 min).

The car is the mode that the participants used mainly to make the most frequent trip, during both Autumn-Winter (26 people) and Spring-Summer (18 people). The difference between the two seasons is small (8 car less circulating in Spring/Summer). Public transport is the second most used mode, but it shows a strong decrease from Autumn/Winter to Spring/Summer time. Bicycle, Moto and PT+Auto are modes only used during the Spring-Summer period. Overall 21 participants change mode between Autumn-winter and Spring-Summer periods. As expected, warmer weather favours the use of sustainable mobility; in fact, during Autumn/winter 26 participants used more pollutant modes as regards the Spring/Summer period (21), as showed in Figure 20.

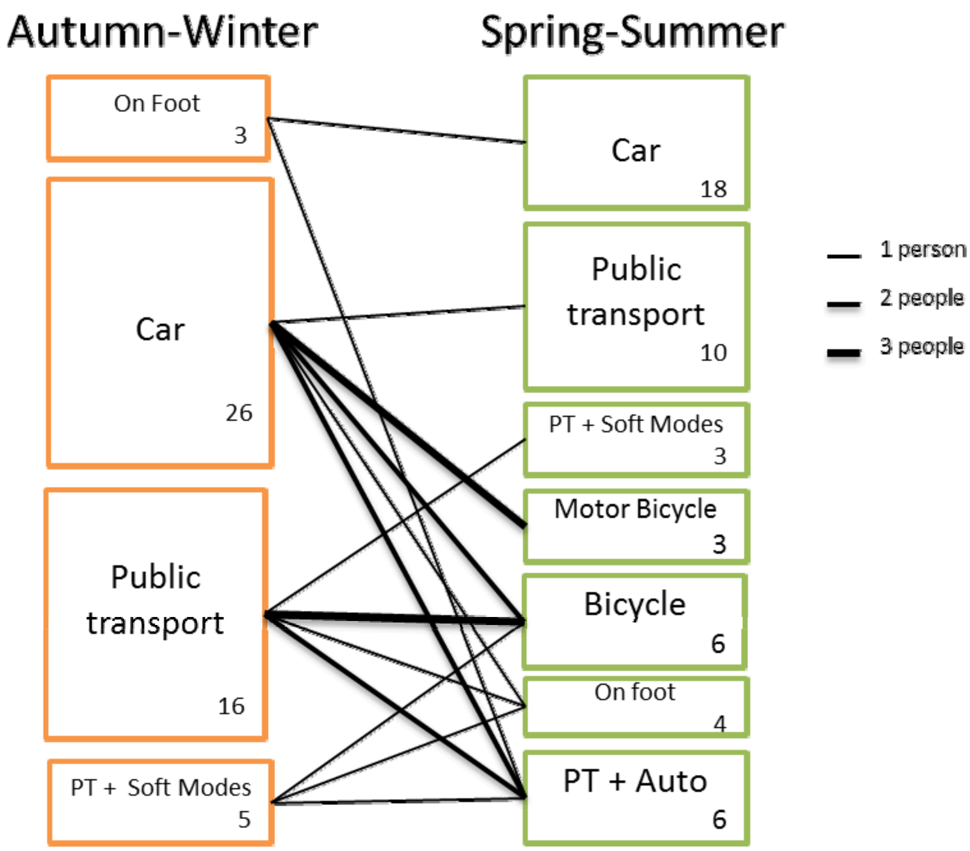


Figure 20 – Mode Change between year periods

Looking at Table 8, it appears that Pt+Soft modes make always longer trips. The distance made on foot dramatically decreases during the Autumn/Winter period compared with the Spring/Summer period.

Table 8 – Average distance by mode

Mode	**Distance Autumn / Winter**		**Distance Summer / Spring**	
	Mean	SD	Mean	SD
Car	11.96	7.71	13.38	7.75
PT	7.47	5.33	8.36	6.35
Personal bike	0	0	4.05	2.71
Walking	0.31	0.21	7.44	10.75
PT+ soft modes	24.40	25.43	30.35	36.70
PT + Auto	0	0	11.41	11.55
Motorcycle	0	0	7.10	4.89

The participants do not declare any intention to change their travel habits (M= 2.44, SD=1.18). As matter of fact, as showed in the Figure 21, only 9 participants agreed with this statement, and, out of the 9 only 3 really wanted to change.

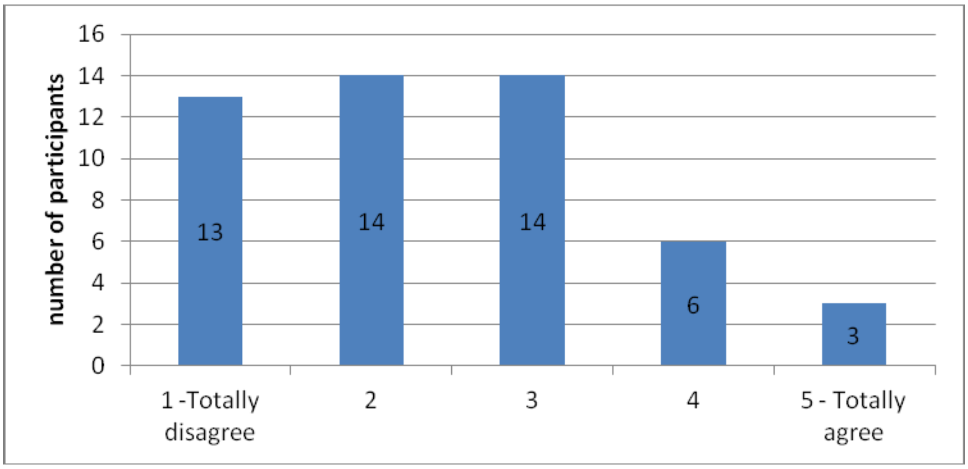


Figure 21 – Intention to change traveling habits

Pollutant or sustainable commuters do not show different intentions to change their travel habits (U = 217.5, p = .058). Neither male nor female show different intentions (U = 260.5, p =.297). Revenue (r_s = .151, p =.294), diploma (r_s = .123, p =.393), age (r_s = .057, p =.694), household size (r_s = .130, p =.370) and number of children (r_s = .0230, p =.874) have not any significant correlation with the intention to change travel habits.

Detours

At least three times per week 27 participants make detours (Figure 22).

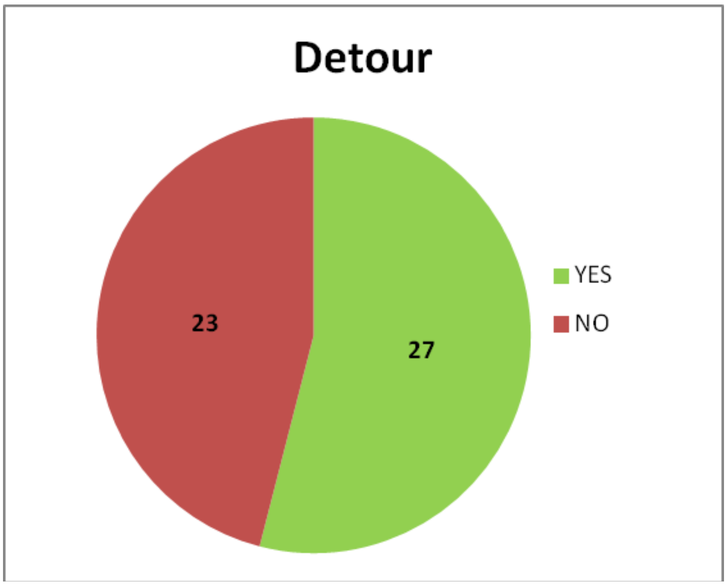


Figure 22- Detour

The mode of transport does not influence making detours. Only people who normally walk make detours.

At least once a week, all the 27 participants that declared that make detours travel for shopping purpose or to visit someone. About 19 of them make detours three or more times a week for leisure. Only 9 participants make detours for children related purposes. The season in which the detours are made is not relevant, only promenade highly increases at Spring/Summer time (Figure 23).

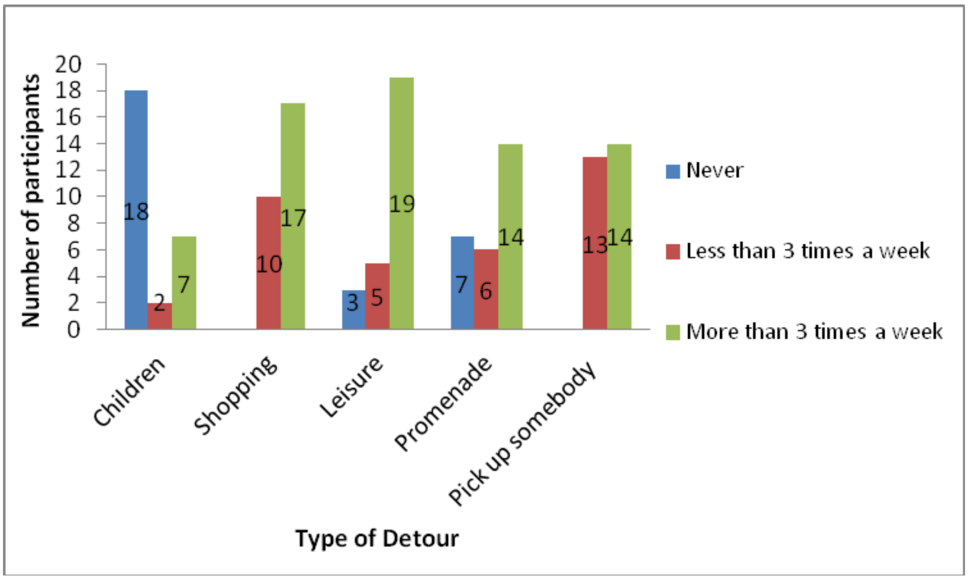


Figure 23 – Reason for detour

Use of transport mode

The car is the mode more used during the Autumn/Winter period, whereas 43 participants use it at least once in the week and 25 persons use it at least 4 times in a week.

The second most used mode is the Public Transport, whereas 33 participants use it at least once a week and 17 use it four or more times a week. Walking is the third mode more often used to travel during this period. Modes like TER, DRM, trottinete and bike-sharing show (Figure 24).

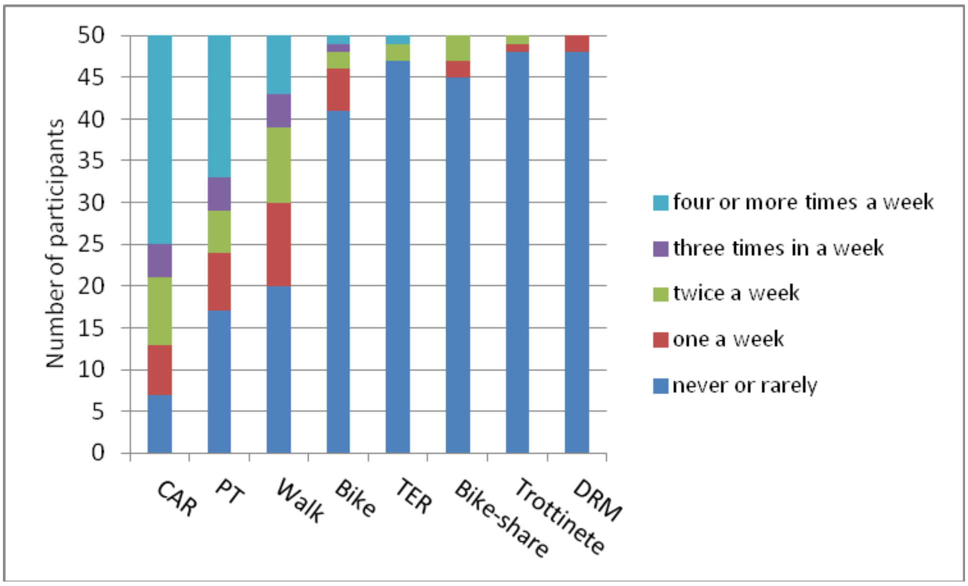


Figure 24 – Mode usage Autumn/Winter

During the Spring/Summer period, the car still remains the most used mode, with 40 participants using at least once in a week. The public transport presents an increase (two more users than in Autumn/Winter) remaining the second more frequent mode. Furthermore, walking, even showing a very tiny decrease, still is the third mode more often used. TER, DRM, trottinete and bike-sharing show the same tendency of Autumn/Winter (very low usage) but with small increase (Figure 25).

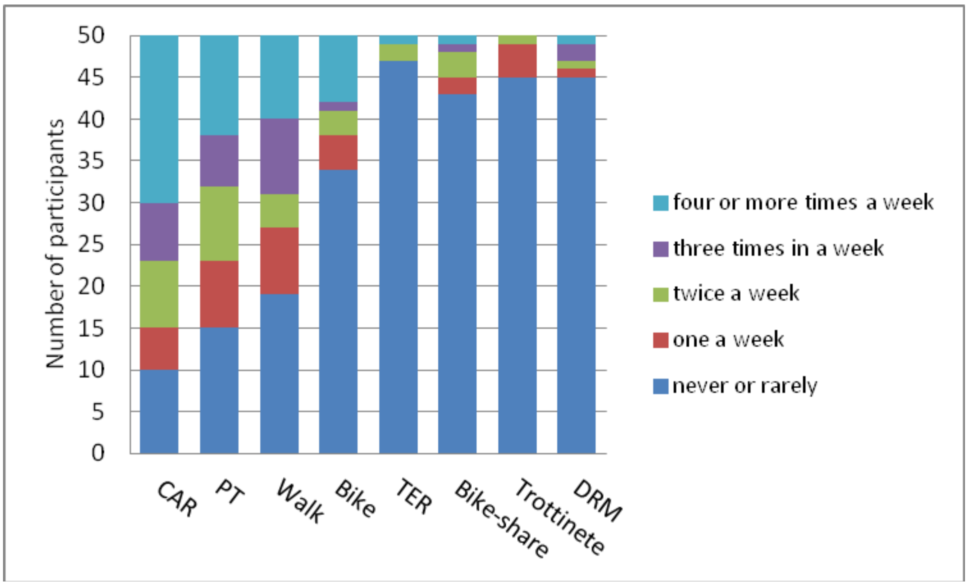


Figure 25 - Mode Usage Spring/Summer

Again, during the weekends the car is still the mode more often used, with 44 participants using at least one weekend per month and 23 using all the weekends. In additions, weekends present a slight difference compared to the working days; the second most used mode is walking. TER, DRM, trottinete and bike-sharing once more show a very low use (Figure 26).

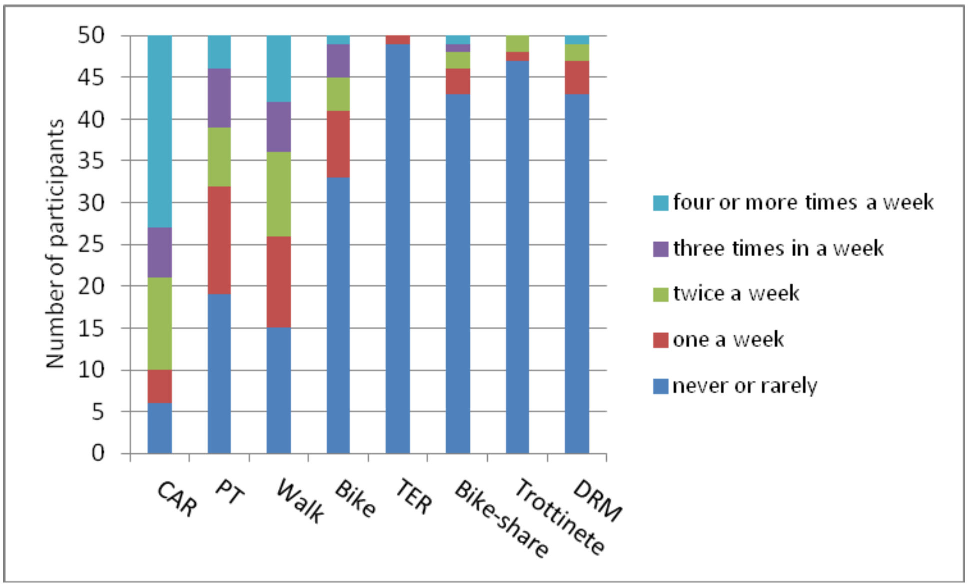


Figure 26 – Modes used during the Weekend

The three most often used modes of transport were selected for a further analysis: car, public transport and walking.

Car – The use of car shows a stable trend all along the year and it is the mode more often used. Looking at the Figure 27 it is easy to identify that very few people never use the car.

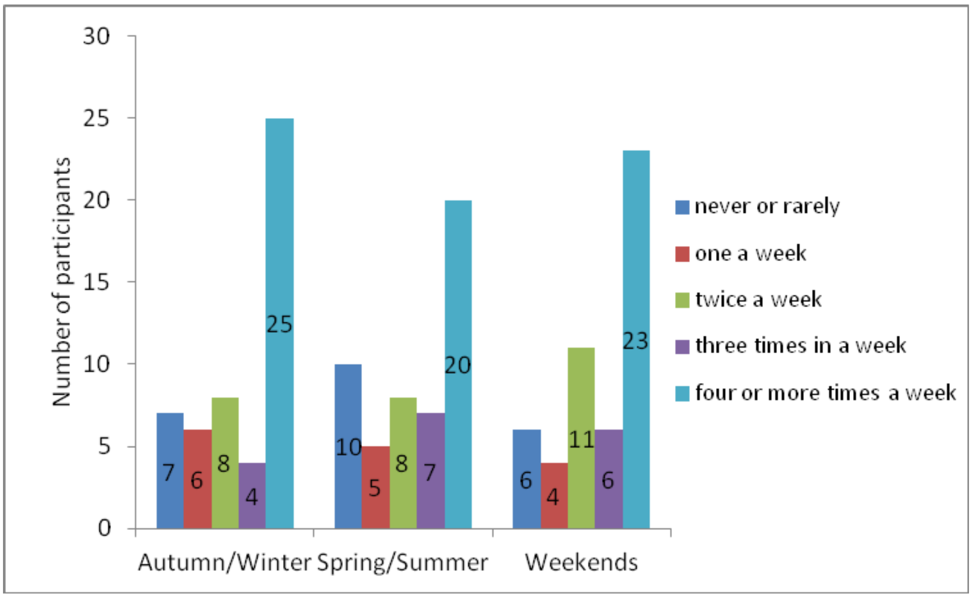


Figure 27 – Car use

A t-test for independent-samples showed that the scores were significantly higher (*t*(49) 2.47, *p* = .017) in Autumn/Winter (M_{aw}= 3.68, SD_{aw}= 1.53) than in Spring/Summer (M_{ss}= 3.44, SD_{ss}= 1.58),. This means that in general the participants tend to use more the car in Autumn/winter season that than in the Spring/Summer.

Public Transport – Public transport is largely used during the working days, from 33 to 35 people use it at least once a week; its use decreases during the weekend where only 31 people use it at least one weekend a month (Figure 28).

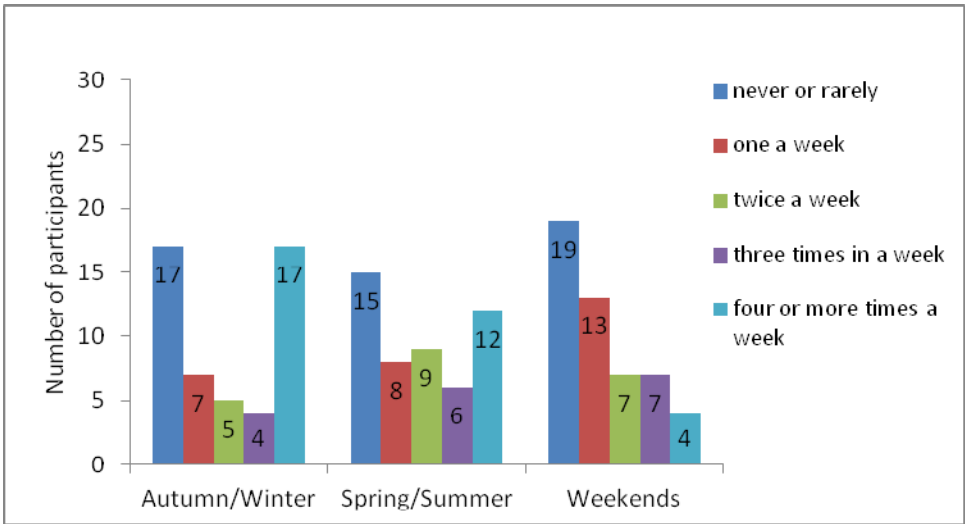


Figure 28 – PT use

A Wilcoxon Signed-ranks test showed that there is not any significant differences (Z = .884, p = .337) between the PT ridership in Autumn/Winter (Mdn = 2) and in Spring/Summer (Mdn = 3).

Walking – It is the third mode more often used, stable all year long: from 30 to 35 people walk at least once a week. With a small increase during the weekend (Figure 29).

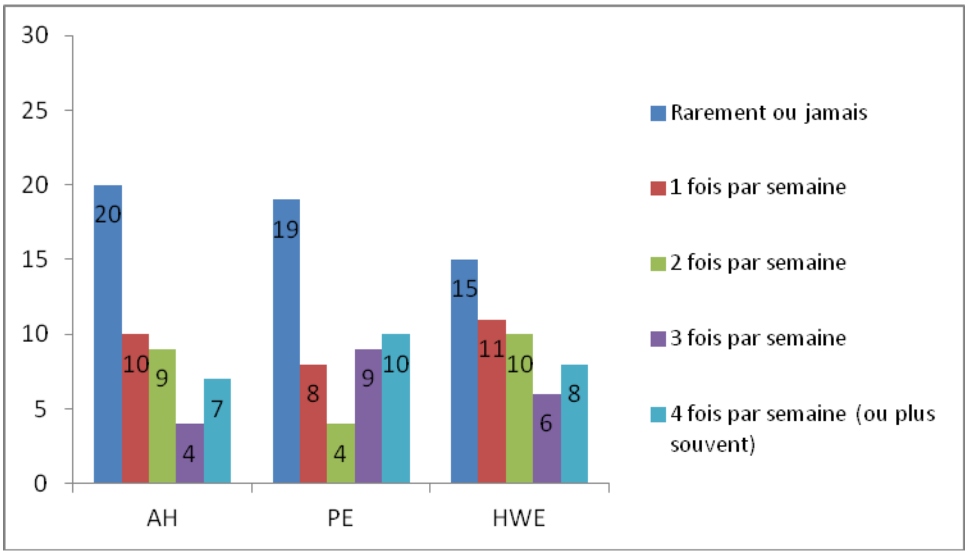


Figure 29 – Walking use

A Wilcoxon Signed-ranks test showed that people walk significantly more (Z = 2.274, p = .023) during the Spring/Summer (Mdn = 3) than in the Autumn/Winter period (Mdn = 2.5).

Reasons for modal choice

The Figure 30 summarizes the participants' assessment of the reasons modal choice. The green line represents the number of participants who consider the reason important, the blue line shows the number of participants who consider neither not important or important the reason and the red line reports the number of participants who consider not important the reason.

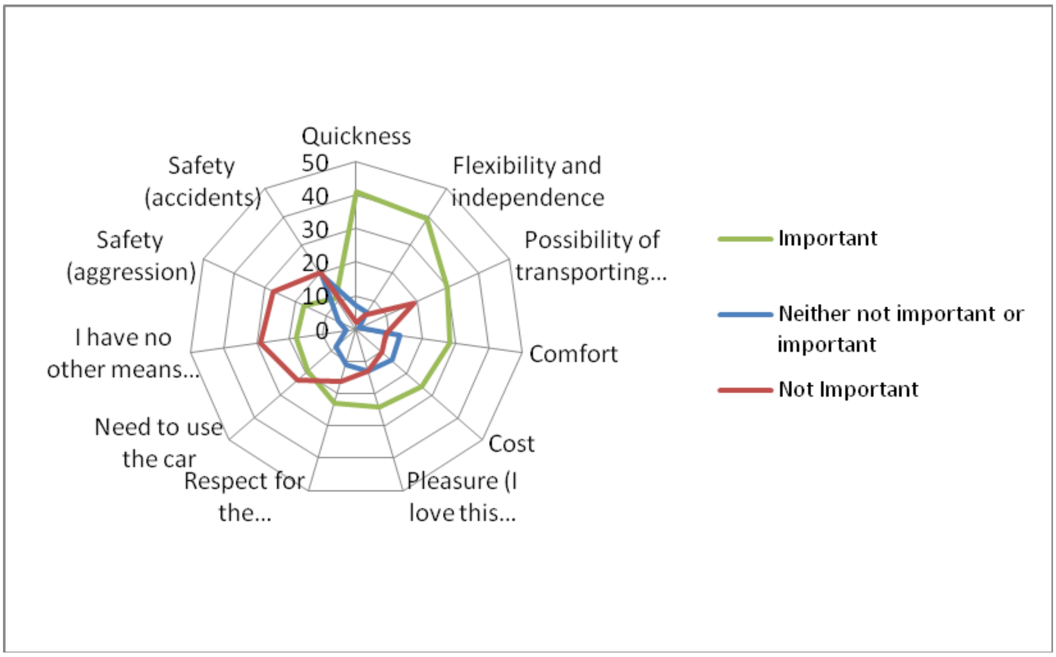


Figure 30 – Reasons for choosing the transport mode

The overall most important reasons for choosing the mode were:

1- quickness (41 persons);
2- flexibility and independence (39 persons);
3- possibility of transporting people and objects (30 persons).

The overall reasons marked as not important were:

1- no other mode available (29 persons);
2- safety - aggression (27 persons);
3- safety – accidents (20 persons).

When it was asked if there were other reasons for choosing their mode, the participants mentioned five times that PT were not available at their departure/arrival, four times work-related, two times because of the weather and three times for other factors.

For understanding the relations between the reasons and going in depth in the modal choice, the Pearson correlation matrix was built (Table 9). It is possible to verify that a big number of reasons have significant relations among them: safety (accidents), safety (aggressions), comfort, possibility of transporting people or objects and need to use the car. The reason "I need to use the car" is almost correlated with all the other reasons.

Table 9 – Reasons Correlation matrix

Reasons	Variable	sec_acc	sec_agr	cost	Quick	Comf	Pleas	Flex	Environ	No_oth	peo_obj
Safety accidents	sec_acc	1									
Safetyaggressions	sec_agr	.744**	1								
Cost	cost	.157	.102	1							
Quickness	Quick	.197	.243	.227	1						
Comfort	Comf	.410**	.573**	-.005	.438**	1					
Pleasure	Pleas	.277	.169	.360*	.187	.144	1				
Flexibility and independence	Flex	.325*	.449**	-.038	.246	.250	.224	1			
Respect for Environment	Environ	-.046	-.250	.514**	-.069	-.201	.285*	-.050	1		
No other mode available	No_oth	-.054	.190	-.111	.081	.146	-.128	.048	-.207	1	
Possibility of transporting people or objects	peo_obj	.438**	.503**	-.064	.073	.554**	.220	.492**	-.084	.113	1
Need to use car	car	.347*	.496**	-.322*	.184	.510**	-.014	.335*	-.410**	.318*	0.425**

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

In synthesis, work is the principal purpose for commuting. The car is the mode more often used during the year for any purpose. Participants only ride bicycles and motorcycles on the summer/spring period. Interestingly car strongly decreased between Autumn/Winter and Spring/Summer periods.

The most important reasons for choosing the most frequent mode were quickness, flexibility/independence and the possibility of transporting people or objects. This can be seen as positive prelude as Smartmoov' wants to provoke a modal swift, guaranteeing the quickness and flexibility when travelling that the participants seek when commuting.

From the 26 pollutant commuters, on Autumn/Winter, only 6 showed intention to change mobility habits, which is a negative outlook for the implementation of Smartmoov'. In addition, from the 24 sustainable commuters only 3 intend to change mobility behaviour, being this fact positive for the mobility in the city of Lyon.

1.2. Differences between travellers who use sustainable or pollutant modes

There were significant differences between polluters and sustainable travellers. To better understand such topic six issues were analysed: Reasons, Statements, Real-time information, Technological familiarity and interest, Smartmoov' and Personal Characteristics.

Reasons

Out of the eleven reasons, six of them showed different significant average values. The reasons were comfort, safety-aggression, flexibility and independence, not having other modes available, the possibility to transporting people or objects and the compulsory need to use the car. Since the variables showed high values of Kurtosis and Skewness, it was not possible to assume a normal distribution; thus the Mann-Whitney test (U) was used to assess the differences between users of polluters and sustainable. The Table 10 summarizes the significant Mann-Whitney findings.

Table 10 – Significant reasons to use sustainable or pollutant modes (non-parametric results)

	Reasons Variables					
	Have to use car	Safety Aggressions	Comfort	Flexibility and independence	No other mode available	Possibility of transporting people or objects
Mann-Whitney U	29	177.5	152.5	211	207.5	166
Wilcoxon W	329	477.5	452.5	511	507.5	466
Z	-5.68	-2.686	-3.2	-2.199	-2.117	-2.949
Asymp. Sig. (2-tailed)	.000	.007	.001	.028	.034	.003

A Mann-Whitney test showed that the reason, "need to use the car", was greater for participants who were pollutant (Mdn = 4.5) than for participants who were sustainable (Mdn = 1), (U = 29, p < .001, r = -.80).

The reason "safety aggressions" was less important for participants who ride sustainable modes (Mdn = 1.5) than for participants who ride pollutant modes (Mdn = 3), (U = 177.5, p = .007, r = -.38).

The reason comfortable was of greater importance for participants who used pollutant modes (Mdn = 4.5) than for participants who used sustainable modes (Mdn = 3), (U = 152.5, p = .001, r = -.45).

When assessing the "flexibility and independence" participants for both polluters (Mdn = 5) and sustainable (Mdn = 4) users was an important feature, but significantly greater for the polluters, (U = 211, p = .028, r = -.31).

The reason "no other available mode" is less important for sustainable riders (Mdn = 1) than to polluters (Mdn = 3), (U = 207.5, p = .034, r = -.30).

The "possibility to transport people or objects", is very important for polluters (Mdn = 4.5) while it is not important for sustainable users (Mdn = 2). A Mann-Whitney test showed a median distinction between modes, (U = 166, p = .003, r = -.42).

Table 11 summarizes the reasons that presented significant differences between the polluters and sustainable users. The results are represented by the median value since these variables did not resemble the Gaussian distribution.

Table 11 – Different perspectives about the reasons of modal choice

Field	*Statements*	*Pollutant participants*	*Sustainable participants*
Reasons	I have to use my car for my most frequent trip	**AA**	**DD**
	Safety aggression	**N**	**D**
	More comfort	**AA**	**N**
	Flexibility and independence	**AA**	**A**
	I have no other means available	**N**	**DD**
	Possibility of transport people or objects	**AA**	**D**

Legend: **AA**- Totally Agree; **A**- Agree; **N**- Neutral; **D**- Disagree; **DD**- Totally Disagree

Personal Mobility Attitudes

Pollutant riders agree that their travel takes too long while the sustainable riders have an undecided position - $M_P = 3.692$ ($SD_P = 1.087$), $M_S = 2.667$ ($SD_S = 1.494$), ($t(41) = 2.757$, $p = .009$, 95% CI [0.507, 2.250]) with equal variances not assumed and confirmed by the non-parametric test of Mann-Whitney ($U = 438$ $p = .012$).

When asked if time spending travelling, in their perspective, was a waste of time pollutants commuters, $M_P = 3.731$ ($SD_P = 1.282$), tend to agree and the sustainable commuters are undecided, $M_S = 2.625$ ($SD_S = 1.279$). We can reject the idea that polluters and sustainable users have an equal opinion $t(48) = 3.050$, $p = .004$, 95% CI [0.377, 1.835], confirmed by the non-parametric test ($U = 456.5$ $p < .001$).

The polluters $M_P = 3.577$ ($SD_P = 1.332$) think that they spend too much money while the sustainable riders $M_S = 2.333$ ($SD_S = 1.373$) have an opposite opinion, disagreeing that they spent excessively. This difference is supported by the results of t-test $t(48) = 3.251$, $p = .002$, 95% CI [0.474, 2.013] and confirmed by the non-parametric test ($U = 456.5$, $p = .002$).

The Polluters $M_P = 4.231$ ($SD_P = 0.765$) like to travel by car while the sustainable riders $M_S = 2.667$ ($SD_S = 1.274$) tend to have an undecided position. The differences between the two groups are significant based on the values of the t-test ($t(37) = 5.210$, $p < .001$, 95% CI [0.956, 2.172] equal variances cannot be assumed) as confirmed by the Mann-Whitney test *(U* $= 523.5$, $p < .001$).

When it was asked if the respondents prefer to move faster, even if it causes a slight stress, polluters commuters tend to agree, $M_P = 3.538$ ($SD_P = 1.208$), and sustainable commuters tend to be undecided, $M_S = 2.583$ ($SD_S = 1.472$). This differences are significant: t-test $t(48) = 2.517$, $p = .015$, 95% CI [0.197, 2.718] and com firm by Mann-Whitney ($U = 431$, $p = 0.018$).

Sustainable participants tend to totally disagree (Mdn = 1) that feel like wasting time when riding a bike. Besides pollutants also disagree (Mdn = 2) a Mann-Whitney test show that there are significant differences between the two groups (U = 436 p = .010).

Sustainable users, M_S= 1.917 (SD_S = 1.139), tend to disagree that taking the TCL or TER (excluding waiting time) is a wasting of time while the polluters (M_P = 2.731; SD_P = 1.282), have an undecided position. This different opinion is significant (t-test t(48) = 2.366 , p = .022, 95% CI [0.122, 1.506]) as also confirmed by the Mann-Whitney test U = 428, p = .019.

When inquired if they feel like wasting time when traveling by car, the polluters are undecided (M_P = 3.038; S_P = 1.038), and sustainable commuters (M_S= 2.333; SD_S = 1.373), disagree. Looking at the values of the t-test (t(42) = 2.038 , p = .048, 95% CI [0.048, 1.404], equal variances cannot be assumed) and the Mann-Whitney test (U = 412.5, p = .044) reject the idea that the two groups have the same opinion on this subject.

The sustainable riders (M_S= 3.542; SD_S = 1.318), tend to agree that they prefer to move peacefully, even if it takes a little longer. The polluters (M_p = 2.769, SD_P = 1.336) tend to have an undecided opinion. Supported by the t-test values (t(48) = -2.056, p = .045, 95% CI [-1.528, -0.017]) and by the Mann-Whitney test (U = 209, p = .041) it is possible to state that the groups have different opinions.

The polluters (Mdn = 4) love driving when performing their most frequent trip. On the opposite side sustainable commuters (Mdn = 1) tend to disagree with that statement. This statement did not show the normality assumptions, therefore, only non-parametric test was carried out. Nevertheless we can conclude that the two groups are median distinct based on the Mann-Whitney test (U =553, p < .001).

The sustainable travellers disagree (M_S= 1.833; SD_S = 1.090) that they would like to carpool on their most frequent trip while the polluters have a neutral position instead (M_P = 2.769; SD_P = 1.275). Based on the paired t-test (t(48) = 2.779, p = .008, 95% CI [0.259, 1.613]) and the Mann-Whitney test (U = 443.5, p = .008) we can assume that this different opinion is significant.

The polluters tend to disagree (M_P = 2.077; SD_P = 1.197) that they would like to use Public Transport on their most frequent trip. Sustainable commuters are undecided (M_S= 3.375; SD_S = 1.439), that they would like to use Public Transport on their most frequent trip. This different opinion tendency is significant (t(48) = -3.477, p = .001, 95% CI [-2.049, -.548]); (U = 157, p = .002).

The polluters (M_P = 2.000; SD_P = 1.166) did not like to walk for their most frequent travel. Sustainable users showed a neutral position (M_S= 3.083; SD_S = 1.381). Once more this difference is statistically significant (t(48) = -3.005, p = .004, 95% CI [-1.808, -.359]); (U = 171.5, p = .005).

The Table 12 summarizes the findings about personal mobility attitudes that showed significant differences between polluters and sustainable commuters. The values are based on the mean value for each statement. The statements related to wasting time when "I take the bike or Vélo'v" and "I love drive on my most frequent trip" were not normal distributed, therefore the values are expressed using the median.

Table 12 – Personal mobility attitudes differences between pollutant and sustainable users

Field	*Statements*	*Pollutant participants*	*Sustainable participants*
Personal Mobility Attitudes	My usual travel takes too long	A	N
	For me, travel time is waste of time	A	N
	I spend too much money for my regular travels	A	D
	I like to travel by car	A	N
	I prefer to move fast as possible, even if it causes me a little stress	A	N
	I feel wasting time when I take the bike or Vélo'v *	D	DD
	I feel wasting time when I take the TCL or TER (excluding waiting time)	N	D
	I feel wasting time when I travel by car	N	D
	I prefer to move peacefully, even if it takes me a little longer	N	A
	I love drive on my most frequent trip *	A	DD
	I like to carpool on my most frequent trip	N	D
	I like to do my most frequent travel with Public Transport	D	N
	I like to walk on foot to my most frequent travel	D	N

Legend: *based on median values **AA**- Totally Agree; **A**- Agree; **N**- Neutral; **D**- Disagree; **DD**- Totally Disagree

A logistic regression was used to understand the ability of attitudes related to the personal mobility to predict the mode used by the participants [1].

$$Y_i = \begin{cases} 1 & \text{Sustainable user} \\ 0 & \text{Polluter user} \end{cases} \qquad [1]$$

A forward stepwise method has been used. "I like to travel by car", "I take the best out of time I spent commuting", "I love drive on my most frequent trip" and "I like to walk on foot to my most frequent travel" were added to the model (Table 13). The other statements were left out of the analysis at the last step because had significance values larger than .05.

As a further check, a model using backward stepwise method was built. The two methods choose the same variables, so we can be fairly confident that the model found is a good model.

Table 13 – Model predicts the modal choice using attitudinal variables

Predictor	Coefficient	SE	Coef/S.E.	*p*-value	Exp(coef)	95% CI Lower-BND	95% CI Upper-BND
a. I like to travel by car	1.729	.819	2.11	.002*	5.64	1.08	29.3
b. I take the best out of time I spent commuting	-1.151	.523	-2.20	.010*	.316	.110	.906
c. I love drive on my most frequent trip	1.763	.611	2.89	.000*	5.83	1.70	19.9
d. I like to walk on foot to my most frequent travel	-.969	.500	-1.94	.027*	0.380	.139	1.04
Constant	-5.154	2.96	-1.74	.021*	$0.578E^{-02}$	$.149E^{-04}$	2.24

Note: * sig. at .05

To better understand whether the model adequately describes the data, the Hosmer-Lemeshow test and the C.C. Brown test were calculated. Table 14 shows that the model adequately fits the data, because the significant value is bigger than .05.

Table 14 – Goodness-of-fit Test

Test	Chi-square	df	Sig.
Hosmer and Lemeshow	10.263	8	.247
C. C. Brown	1.516	2	.468

The model is reported in equation [2]:

$$\Pr[\textit{polluter user}] = \frac{e^{-5.154+1.729a-1.151b+1.763c-.969d}}{1+e^{-5.154+1.729a-1.151b+1.763c-.969d}} \qquad [2]$$

Where the odds of be a polluter user increase by a multiplicative factor of 5.64 (Exp(a) = 1.729) per one higher score on "I like to travel by car" and by 5.83 (Exp(c) = 1.763) per one higher score on "I love drive on my most frequent trip". Declining by a multiplicative factor of .316 (Exp(b) = -1.151) per one higher score on "I take the best out of time I spent commuting" and by .380 (Exp(d) = -.969) per one higher score on "I take the best out of time I spent commuting".

Table 15 shows the results of the logistic regression model. Using the default threshold, BMDP will classify a subject into "sustainable user" category if the estimated probability is .5 or more. On the other hand, the BMDP will classify a subject into the "polluter user" category if the estimated probability is less than .5. Cells on the diagonal are correct predictions and cells off the diagonal are incorrect predictions. Overall, 92.0% of the cases are correctly classified.

Table 15 – TPB Logistic regression model classification table

Observed	Predicted		
	Polluter user	Sustainable user	Percentage Correct
Polluter user	24	2	92.3
Sustainable user	2	22	91.7
		Overall Percentage	92.0

It should be remembered that the classifications based upon the cases used to create the model tend to be too "optimistic" as their classification rate can be inflated. This approach allowed to build the ROC curve. The ROC Curve procedure provides a useful way to evaluate the performance of classification schemes that categorize the cases into one of the two groups. The ROC curve is a visual index of the accuracy of the predicted values and the more curve lies above the reference line, more accurate the test is. The area under the ROC curve measures the probability of the correct risk rating of a randomly selected pollutant/sustainable pair of subscribers. In this example, the four predictors correctly predict pollutant and sustainable mode users with a probability of 97.1%.

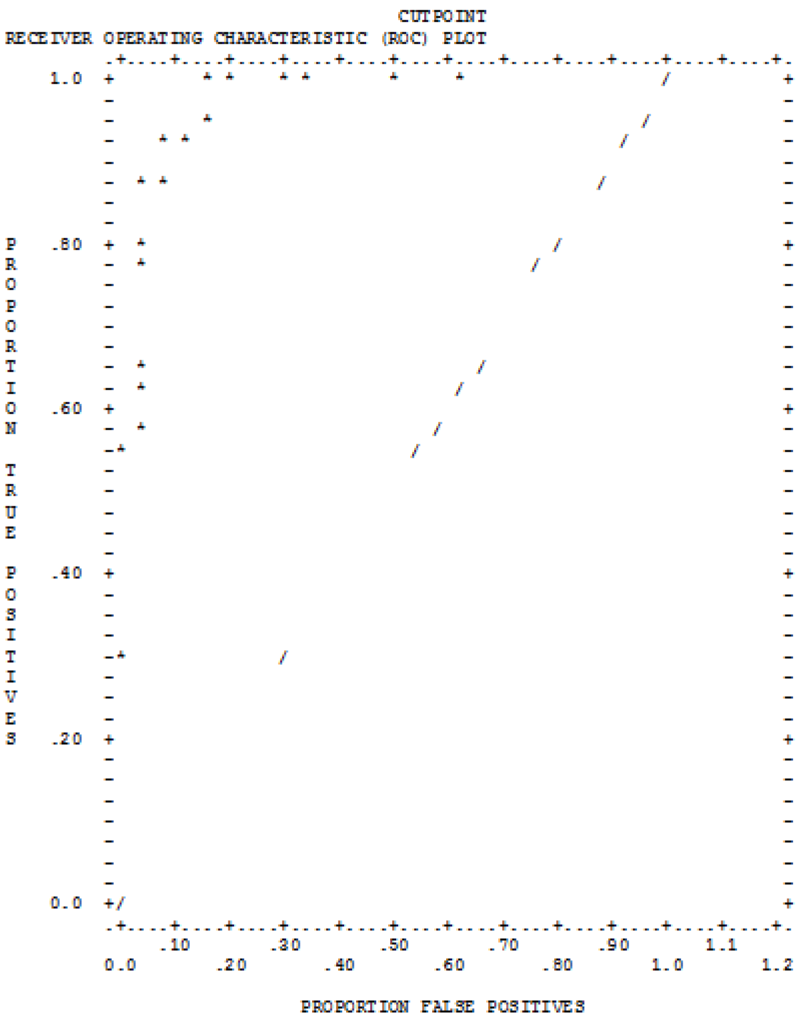


Figure 31 – ROC curve personal mobility attitudes.

To synthesize, the model tell us that we can predict the of mode use: polluters are more likely to score higher on liking to use the car and drive the car and less likely to score higher on taking the best out of the commuting time and enjoying to walk comparing to the sustainable commuters.

Real-time

The polluters (M_P = 3.115; SD_P = 1.366), are undecided if real-time information about public transport would induce them to use it more. Instead, sustainable commuters (M_S= 3.875; SD_S = 1.296) consider that real-time information on PT would increase their PT patronage. The statistic tests proof that polluters appraise less the availability of this information than the sustainable commuters ($t(48)$ = -2.013, p = .050, 95% CI [-1.518, -0.001]; U = 213.0, p = .048).

The polluters agree (Mdn = 4) that the availability of traffic real-time information would increase their use of the car. Sustainable participants have a complete different opinion disagreing (Mdn = 2) that this kind of information would increase their car patronage. A Mann-Whitney test proofs that this difference are significant (U = 495.5; $p < .001$).

Table 16 shows the two questions related to the effects of real-time information on the mobility that showed significant differences between polluters and sustainable users. The first row reports average values while second row median values.

Table 16 – Pollutant and sustainable user real-time perspectives

Field	*Statements*	*Pollutant participants*	*Sustainable participants*
Real-time	I would use the PT more often if I had real-time information on schedules and passes	**U**	**A**
	I would use my car more often if I had real-time traffic information*	**A**	**D**

Legend: *based on median values **AA**- Totally Agree; **A**- Agree; **U**- Undecided; **D**- Disagree; **DD**- Totally Disagree

Technological familiarity and interest towards technology

Polluters consider themselves as expert users of computers (Mdn = 5) while the sustainable users asses think to be simple good users (Mdn = 4). A Mann-Whitney test shows that there is a significant difference in how these two groups assess themselves (U = 409, p = .035).

All the participants think to be in general poor users of E-books, but from the data show that the polluters consider themselves as limited users (M_P = 2.462, SD_P = 1.421), and the sustainable users as non-users (M_S= 1.625, SD_S = .770). This difference is also significant $t(48)$ = 2.615, p = .013, 95% CI [0.190, 1.483] - equal variances not assumed - and U = 416, p = .033).

About the use of the smartphones the polluters (M_P = 4.269, SD_P = .827) think to be good users and the sustainable commuters (M_S= 3.458, SD_S = 1.215) competent users. Again the difference between the two groups is significant ($t(40) = 2.736$, $p = .009$, 95% CI [0.212, 1.410] - equal variances not assumed – and $U = 435.5$, $p = .011$).

As regards the use of GPS navigator, the polluters (Mdn = 4) tend to consider themselves as good users and the sustainable commuters (Mdn = 3.5) as good/competent users (Mann-Whitney test U = 440.5 p =.009).

About the familiarity of the participants with technological tools, it seems that polluters self-assess themselves more skilled then sustainable users; these findings are reported in the Table 17.

Table 17 – Technologic competences differentiated by pollutant and sustainable riders

Field	*Tools*	*Pollutant participants*	*Sustainable participants*
Familiarity	Desktop/Portable competence **	**Expert user**	**Good user**
	Ebook competence*	**Limited user**	**Non-user**
	Smartphone competence**	**Good user**	**Competent user**
	GPS Navigator competence*	**Good user**	**Competent user**

Legend: *based on median values; **based on mean values

The polluters ($M_P = 3.423$; $SD_P = 1.653$) showed that they have a neutral familiarity with iOS operative system while the sustainable commuters ($M_S= 2.125$, $SD_S = 1.454$) have no familiarity with this operative system. Considering the mean values, the polluters have a significant higher familiarity with iOS than sustainable users as the paired t-test shows ($t(48) = 2.938$, $p = .005$, 95% CI [0.410, 2.187]) and the Mann-Whitney test ($U = 444.5$, $p = .008$) show.

About the need of technological tools in their daily life the two groups, polluters ($M_P = 3.462$; $SD_P = 1.272$) and sustainable commuters ($M_S= 2.585$, $SD_S = 1.176$) were undecided. But in a closer look of the data we acknowledge that the polluters have a neutral positive view, meaning that they almost agree that they need a lot of technological tools in their daily life while the sustainable users have a neutral negative, meaning that they almost disagree that they need technological tools ($t(48) = 2.528$, $p = .015$, 95% CI [0.180, 1.577] and $U = 432$, $p = .017$).

The Table 18 report the technological interests differences.

Table 18 – Technologic interests differentiated by pollutant and sustainable riders

Field	*Statements*	*Pollutant participants*	*Sustainable participants*
Tech interest	I have a good familiarity with iOS	**U**	**D**
	I need lots of technological tools in my daily life	**U+**	**U-**

Legend: AA- Totally Agree; **A**- Agree; **U**- Undecided; **D**- Disagree; **DD**- Totally Disagree

Smartmoov'

Concerning the mobile application, Smartmoov', only one question showed significant differences between polluters and sustainable users.

Sustainable commuters (M_S= 2.500, SD_S = 1.414), disagree that they would limit the environment impacts of their travels stressed by public policy makers. Instead, polluters (M_P = 3.269, SD_P = 1.251) do not know if this policy makers would be pressure to limit their mobility environmental impacts. The opinion of the two groups are significant different ($t(48) = 2.041$, $p = .047$, 95% CI [0.110, 1.527]; $U = 413$, $p = .045$) (Table 19).

Table 19 – Smartmoov' Pollutant and sustainable commuters' perspective

Field	*Statements*	*Pollutant participants*	*Sustainable participants*
Smartmoov'	I expect that public policy makers put pressure on me to limit the environmental impact of my displacement	**U**	**D**

Legend: AA- Totally Agree; **A**- Agree; **U**- Undecided; **D**- Disagree; **DD**- Totally Disagree

Personal Characteristics

The personal characteristics differences of the pollutants and sustainable commuters, show that polluters (M_P = 2.81, SD_P = .567), have more available cars in the household than sustainable commuters (M_S= 1.96, S_S = .624). This difference is statistically significant ($t(48) = 5.042$, $p < .001$, 95% CI [0.511, 1.188] and $U = 509.5$, $p < .001$). Notably, the results shows that the polluters have in average two cars available in the household while sustainable users have only one.

There is, also, a significant association between the type of mode used and the ownership of PT pass [$\chi^2(1) = 13.178$, $p < .01$]. Essentially, who have PT passes tend to use more sustainable modes (Table 20).

Table 20 – Pollutant and sustainable commuters' personal characteristics

Field	*Variables*	*Pollutant participants*	*Sustainable participants*
Personal Characterist	How many cars at your household	**2 cars**	**1 car**
	Ownership of a PT pass	**No Pass**	**Pass**

1.3. Before the Smartmoov' app use

Technology

Almost each participant answered that uses a PC, only one person does not have access to the computer. The ownership of Smartphones is very high, 41 out of the 50 participants have one and only six persons said that they do not use it. From these 41, 22 said that had android and 19 iOS operation system. The use of GPS navigator is also high, 40 persons use it. In addition, the MP3 player presents a high usage (38 people). Instead, Ebook and Tablet are scarily use: Ebook are used by only 4 people and Tablet are used less than by the half of participants (24) (Figure 32).

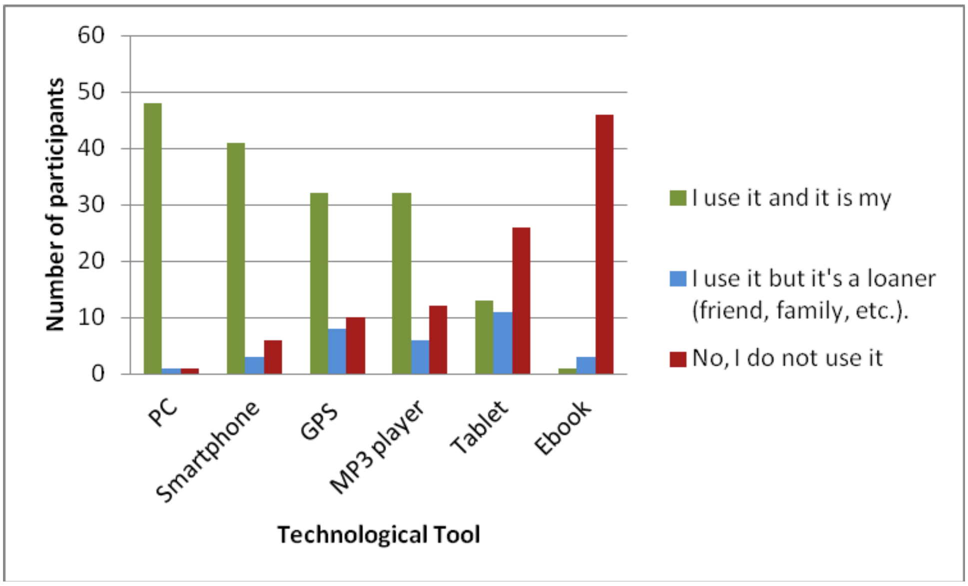


Figure 32 - Ownership of technological Tools

Nine participants declares to use other typologies of technological tools as Playstation, pedestrian GPS, PDA and camcorder.

The participants consider themselves as good users of PC, Smartphones, GPS navigator and MP3 player. These results contrast with the Tablet and Ebook results, positioned on the lower scale of competence (Figure 33).

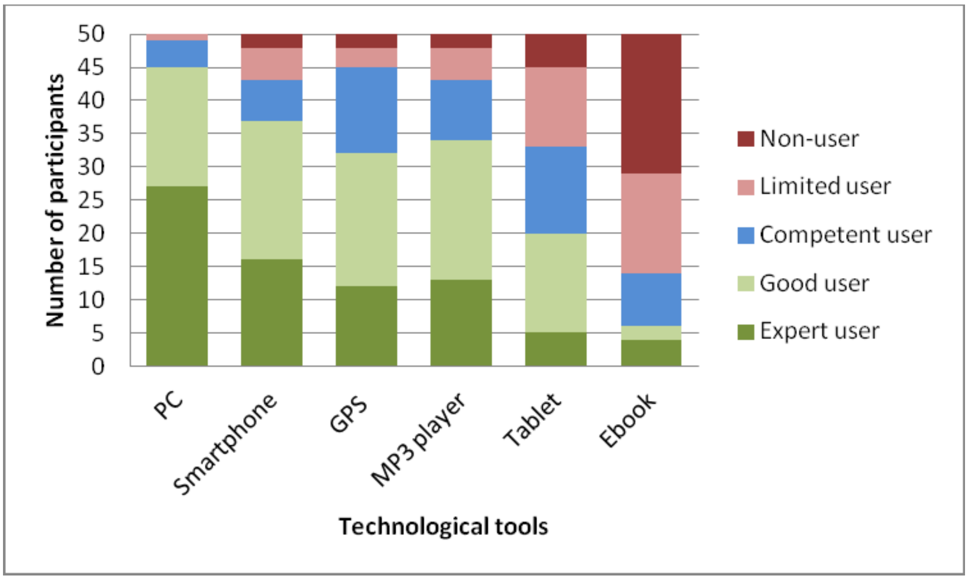


Figure 33- Familiarity with technological tools

There is that is a direct relation between ownership of technological tools and skill using them, explained by the negative and significant Spearman correlation between the tool and skills: [Smartphone $r_S = -.521$, $p < .01$]; [GPS $r_S = -.653$, $p < .01$]; [MP3 $r_S = -.750$, $p < .01$]; [Tablet $r_S = -.430$, $p < .01$].

About sources of information when choosing a route to an occasional place, the majority of the respondents uses internet to get the needed information (44). The second most used tool is the GPS navigator (31) and the third one the App like googlemaps (28).The sense of direction is the “tool” less used, only by 15 participants (Figure 34).

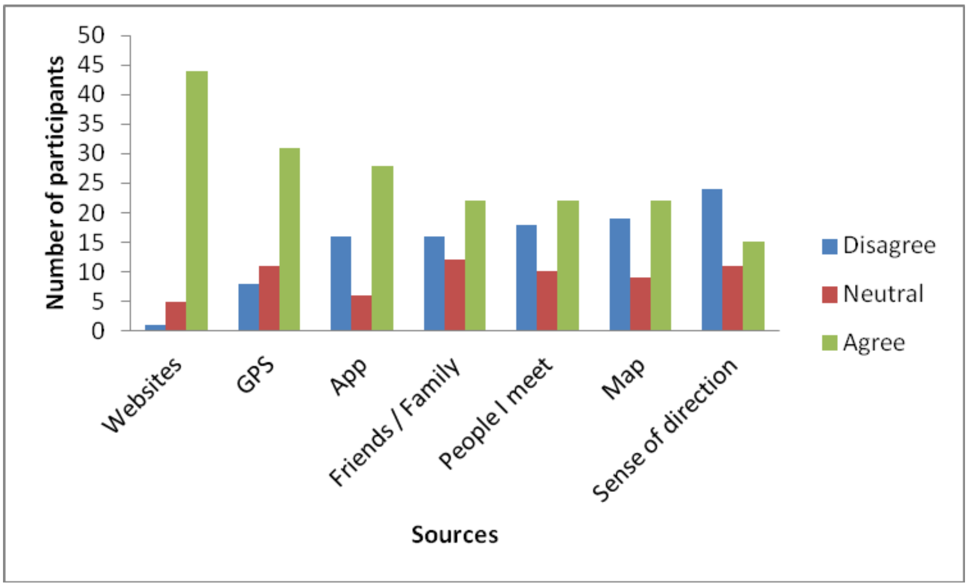


Figure 34 - Information Sources for route choice

The participants showed a high interest towards technological devices, as observed by the high values of the answers to the three questions reported at the Table 21. The smaller mean value is 3.80, mode value is 5 and the median value is 4. The Cronbach's Alpha showed, as well, a good reliability between the three questions (α = .892).

Table 21 - Interest about technology Statistics

	1. I would like to test new technological devices	2. I'm passionate by the potential of new technological Tools	3. I'm interest in technology
Mean	4.34	3.80	4.04
Median	5.00	4.00	4.00
Mode	5	5	5

More than half of the participants (27) agree that apps help them in their daily life observing that apps for daily use are already a reality. More than half of the participants (31) find that some apps are fun. About the willingness to discover new apps, 22 persons like to do it, while 20 not (Table 22).

Table 22 - Interest about technology Statistics (2)

	1. The apps help me in my daily life	2. I find that some apps are fun	3. I enjoy finding new apps
Mean	3.46	3.68	3.04
Median	4.00	4.00	3.00
Mode	5	5	4

The people who already use a certain operative system feel more familiar with its use (Figure 35).

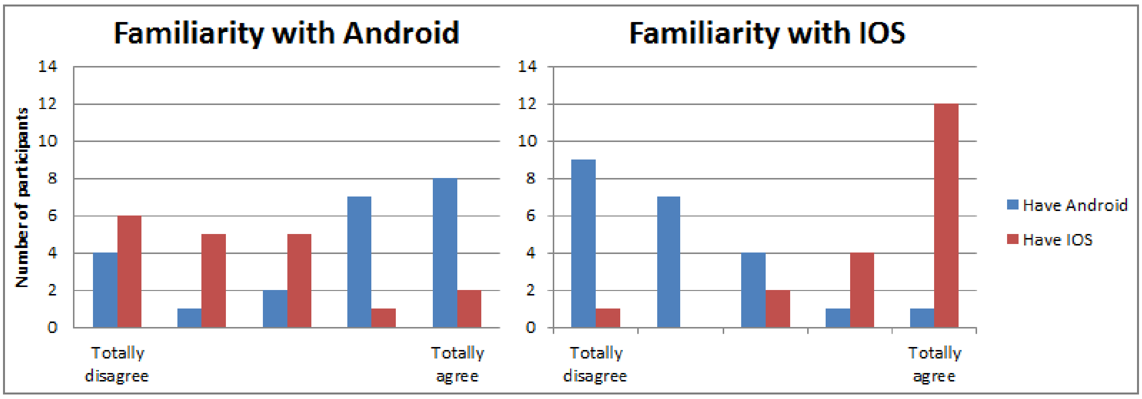


Figure 35 - Familiarity with the operative systems

The need of technological tools in the daily life showed neither agreement or disagreement. The majority of the participants totally disagree that technological tools are useless. The participants also disagree with "I use the same phone until no longer works". There is no general opinion about "I think that excessive use of technology leads to not use my brain (Table 23).

Table 23 - Interest about technology Statistics (3)

	1. I need a lot of technologic tools in my daily life	2. I find that technological tools are useless	3. I use the same phone until no longer works	4. I think that excessive use of technology leads to not use my brain
Mean	3.04	1.46	2.18	2.64
Median	3.00	1.00	2.00	3.00
Mode	4	1	1	1

The participants rely on the information given by the GPS, 28 disagreed with the sentence "I prefer to consider myself to find the best route instead of trusting a GPS". About "I would be lost without my GPS", there is not a clear pattern. The use of apps for helping with the route planning seems already a reality; 33 participants already use apps (e.g. Googlemaps) that help them to plan their travels (Table 24).

Table 24 - GPS and app use Statistics

	1. I prefer to consider myself to find the best route instead of trusting a GPS	2. I'd be lost without my GPS	3. I already use apps (e.g. Googlemaps) that help me for my travel
Mean	2.34	2.82	4.08
Median	2.00	3.00	5.00
Mode	1	1[a]	5

a. Multiple modes exist. The smallest value is shown

In synthesis, familiarity with technological tools will not be a limitation for the success of Smartmoov'. Practically, all participants have a computer and assess themselves as good users. Additionally, more than half of our sample assessed as good users of smartphones, GPS and MP3-players. In fact, only 9 out of 50 participants did not have a smartphone.

Environment

Participants were asked about their opinions and attitudes towards the environment (Table 25). The first statement was if the participants normally think about the environmental impacts when performing their daily actions. The responses of this question followed almost perfectly a normal distribution.

The large majority of the participants (41) said that the air pollution is a real problem in Lyon. Noise pollution is considered, as well, a problem in Lyon, by 35.

There is a slight agreement with the statement "Accidents are a real problem in Lyon", being the mean value 3.54, median 4 and mode 5.

45 out of 50 participants agreed that "Traffic jams are a real problem in the Greater Lyon", and 49 that "Traffic jams worsen air pollution". Consequently, we can affirm that the participants perceive traffic jam as a problem.

37 people agreed that "I believe that sustainable mobility would improve the quality of life in Greater Lyon".

Table 25- Environmental Concerns Statistics

	1. Normally think about environmental impacts	2.Air pollution	3. Noise pollution	4.Accidents	5.Traffic jams real problem	6. Traffic jams worsen air pollution	7.sustainable mobility / life quality
Mean	3.20	4.36	3.98	3.54	4.52	4.74	4.22
Median	3.00	5.00	4.00	4.00	5.00	5.00	4.00
Mode	4	5	5	4	5	5	5

Real-time

The results about the influence of real-time information on the modal choice are not clear, even though, some tendencies can be observed. More real-time information on schedules and passes will slightly increase the use of PT (M = 3.48; SD = 1.37) (27 agreed, 9 were undecided and 14 disagreed). More real-time information on the availability of velov' and stations seems not having an effect on the participants (M = 2.58; SD = 1.51) (28 disagreed and only 15 agreed). More real-time information on the immediate availability of Autolib does not generate effects (M = 2.90; SD = 1.47). As well as real-time information on Carpooling (M = 3.04; SD = 1.52).There are not effects of real-time information on Car use (M = 2.78; SD = 1.46). Table 26 shows the central tendency indicators for the real-time information related with the modes use.

Table 26- Real-time information and used modes

	PT	Velov'	Autolib	Carpooling	Car
Mean	3,48	2,58	2,90	3,04	2,78
Median	4,00	2,00	3,00	3,00	2,00
Mode	5	1	2	1	2

The Figure 36 represents graphically the effects that real-time could have on the use of diverse modes. It seems, in general overlook, that real-time information would increment the use of the Public Transport and has no effect on the use of car and velo'v, being the participants undecided about the effects of the real time on the use of Autolib and carpooling.

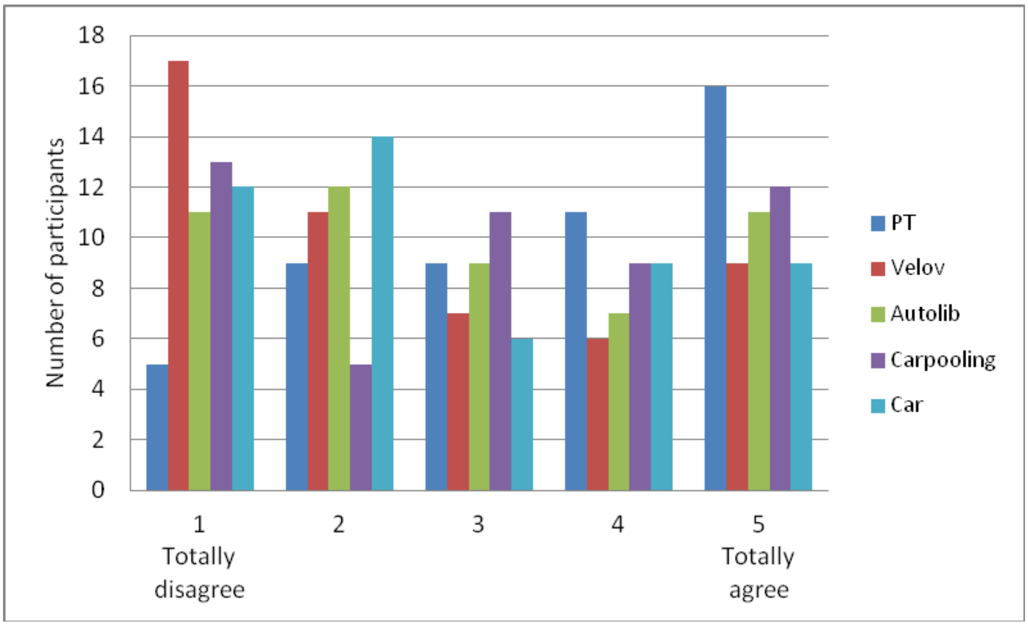


Figure 36– Statements about real-time information per mode

Smartmoov'

The participants showed curiosity about the use application Smartmoov' (M = 4.78; SD = .47), just one person showed undecided.

To investigate the perceptions towards the use of the app three variables were studied. The participants previewed to face some kind of problems in using Smartmoov' daily (M = 4.34; SD = .77). They expect to have a user-friendly app (M = 4.32; SD = .91) and want a user-friendly app (M = 4.82; SD = .44).

The participants intend to use Smartmoov' for planning their occasional trips (M = 4.68; SD = .51) being undecided on its utility for daily trips (M = 3.06; SD = 1.04). This could mean that the people perceive that this app is more helpful for non-systematic trips. The two statements do not show internal consistency (α = -.28).

The respondents are undecided about considering Smartmoov' as a factor to change their travel pattern. The statements were "I feel induced to change my mobility behaviour after using Smartmoov'" (M = 3.06; SD = 1.17) and "Using Smartmoov' will facilitate a change in my mobility behaviour" (M = 3.36; SD = .83). These statements showed a good consistency between them (α = .82). Beside of the general neutral tendency of the answers, 16 participants agree that using this app will be an incentive and 21 that it will facilitate a change of their mobility.

The participants were not willing to pay for using Smartmoov'(M = 2.08; SD = 1.21) (Figure 37).

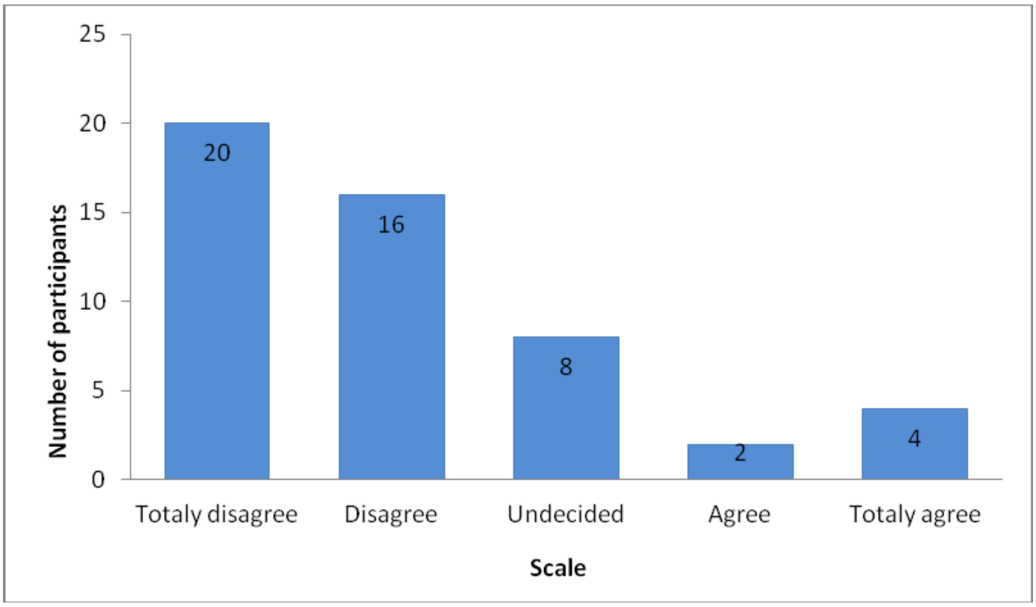


Figure 37 – Willingness to pay for using Smartmoov' app

More the application allow to save time, more the participants are willing to pay (Figure 38 and Figure 39).

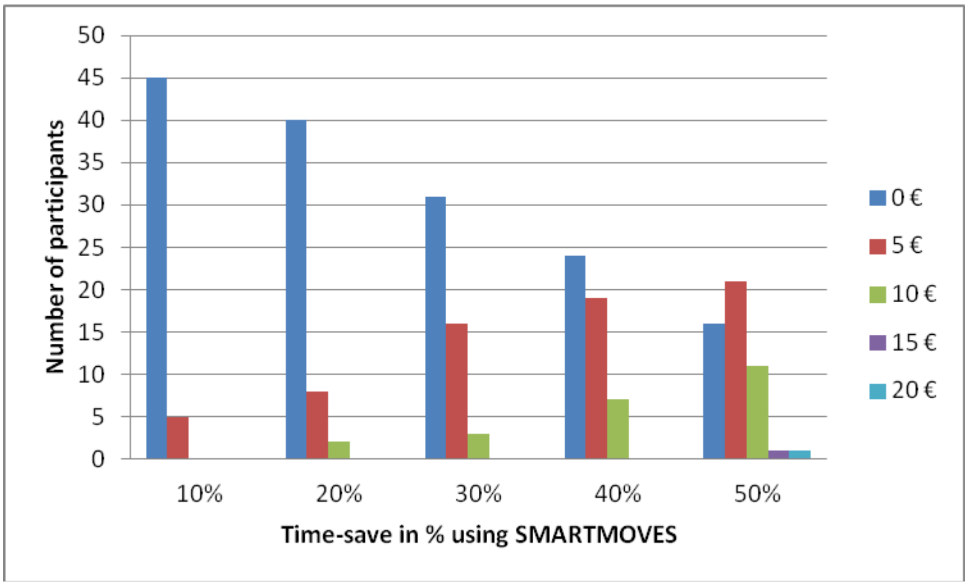


Figure 38 – Willingness to pay per month

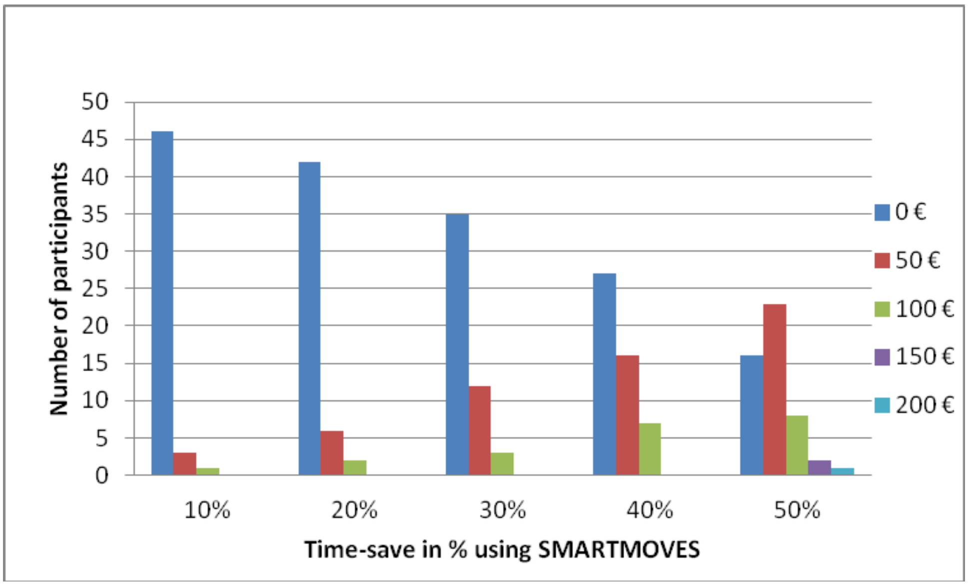


Figure 39 - Willingness to pay per year

The economic success of the app depends of the amount of time that it is able to save.

Three statements investigated to understand the importance of time saving thanks to Smartmoov'. The first statement was about the expectation to save time with Smartmoov' (M = 4.12; SD = .75); the second statement was about saving time with the use of the Smartmoov' (M = 4.48; SD = .76); the third statement was about the intention to use Smartmoov' if it would allow them to save time (M = 4.70; SD = .61). In all the cases respondents agreed with the statements and there is an acceptable reliability between the three statements (α = .707).

Therefore, we can conclude that the time-saving feature of Smartmoov' app is a key part for its success. Clearly, the participants' intention is to use the Smartmoov' if it helps them to shorter the travel times.

The importance of limiting the environment impacts thanks to Smartmoov' was analysed through three statements: "I expect that Smartmoov' helps me to limit the environmental impacts of my travels" (M = 3.70; SD = 1.06); "I would like that Smartmoov' helps me to limit the environmental impacts of my travels" (M = 3.84; SD = 1.11); and "I intend to limit the environmental impacts of my travels using Smartmoov'" (M = 3.66; SD = 1.22). The three statements present an excellent reliability among them (α = .911); respondents agree that using Smartmoov' app will slightly help them to limit the travel environmental impacts of their travels. So, we can conclude that the respondents have a slight intention to limit their travel environmental impacts using Smartmoov' app.

Several statements to understand if the social pressures played any role in the use of the Smartmoov' were provided: "I expect that policy makers incite me to use Smartmoov'" (M = 3.38; SD = 1.16); "I expect that my family and friends incite me to use Smartmoov'" (M = 2.62; SD = 1.14); "I expect that policy makers put pressure on me to limit the environmental impacts of my travels" (M = 2.90; SD = 1.37); and "I expect that my family and friends put me under pressure to reduce the environmental impacts of my travels" (M = 2.20; SD = 1.09). The answers to these statements are very disperse being therefore difficult to extract any strong conclusion on a descriptive level. The only statement that shows some agreement was "I expect that policy makers incite me to use Smartmoov'". The statement with a more stronger disagreement is "I expect that my family and friends pressure me to limit the environmental impacts of my travels", appearing that family and friends will not be a driver for a more sustainable mobility. The statements 1 and 2, social pressure to use Smartmoov', showed a questionable the reliability between them (α = .678). The statements3 and 4, social pressure to reduce the environmental impact of my travels, show good reliability between them (α = .751). In general, it seems that social pressures do not play a role in the use of the Smartmoov' and on the need to reduce environmental impacts of the travels.

1.4. Behavioural constructs for the modal change

In chapter II was discussed and chosen the Theory of Panned Behaviour (TPB) as support theory for this research. TPB state that intentions are the immediate psychological antecedent of behaviour. The intentions derive from a person's evaluation of performing a behaviour (attitude towards behaviour, from now "ATT"), the perceived social pressure surrounds the behaviour (subjective norms, from now "SN"), and the perceived control over factors that may inhibit or facilitate the behaviour' performance (perceived behavioural control, from now "PBC").

To further assess the construct validity and explore the underlying factor structure of the TPB, the exploratory factor analysis was used. Note that the item generation for this measure was guided by the goal of a three factors solution (according to the TPB), as can be seen in Figure 9. Nonetheless, it was chosen to use the exploratory factor analysis (EFA) rather than the confirmatory factor analysis (CFA) given the newness of the application of TPB in the area of changing travellers' behaviour when providing multimodal real-time information; CFA is most useful in later stages of measure development to refine and improve measures (Kahn, 2006).

Hence, EFA guided by three factors solution was used. While acknowledging the possibility of a different factor structure, EFA was used primarily as a tool to assist in the selection of the best and most representative items for the proposed TPB constructs.

Because of the small sample size it was used the whole sample to conduct the EFA. Using the whole sample it was not possible to run any confirmation or replication of findings. Therefore, our analysis can result in finding by chance and the stability of the factor structure would be unknown. The results would then await for confirmation in future researches conducted using the found items to measure the TPB constructs.

The small sample size could be problematic for this analysis, as some recommendations call for at least 100/150 participants for the EFA, or a minimum ratio of 5 cases per item. As there are

50 participants only 10 items were selected as psychological drives of intentions to fulfil the minimum ratio per items.

Before conducting the factor analysis, all the 10 items were examined and deemed appropriate for the factor analysis on the basis of means, standard deviations, kurtosis and skewness (Figure 40).

Figure 40 – Descriptive analysis of the items

Items	mean	S.D	Skewness	Kurtosis
I expect that my family and friends put me under pressure to reduce the environmental impact of my travels	2.20	1.09	.674 (S.E.= .337)	-.01 (S.E.= .662)
I don't love driving for my most frequent trip	3.26	1.56	-.218 (S.E.= .337)	-1.401 (S.E.= .662)
I expect that policy makers incite me to use Smartmoov'	3.38	1.16	-.557 (S.E.= .337)	-.212 (S.E.= .662)
I like to use the PT for my most frequent trip	2.70	1.46	.303 (S.E.= .337)	-1.197 (S.E.= .662)
I expect that my family and friends incite me use Smartmoov'	2.62	1.14	.350 (S.E.= .337)	-.818 (S.E.= .662)
I would use the PT more often if I had real-time information	3.48	1.37	-.399 (S.E.= .337)	-1.127 (S.E.= .662)
I expect that policy makers put pressure on me to limit the environmental impacts of my travels	2.90	1.37	.089 (S.E.= .337)	-1.201 (S.E.= .662)
I don't like to travel by car	2.52	1.30	.684 (S.E.= .337)	-.422 (S.E.= .662)
I would use more the velov' if the real-time was available	2.58	1.51	.467 (S.E.= .337)	-1.250 (S.E.= .662)
I want that Smartmoov' help me to reduce the environmental impacts of my travels	3.84	1.11	-.596 (S.E.= .337)	-.610 (S.E.= .662)

A Principal components analysis (PCA), as opposed to principal axis analysis (PAF), was used to explore the factor structure of the TPB. PCA was chosen because "is possible to compute an individual person's score on a principal component, whereas it is not possible to do so for a common factor" (Fabrigar et al., 1999, p. 275).

Rotated solutions are usually preferable because they create a more even distribution of the variance accounted for among factors, increase the interpretability of factors and make variables load highly on few factors as possible (Kahn, 2006). After considering whether to use an orthogonal (e.g. varimax, quartimax) or oblique (e.g. promax) rotation, quartimax rotation was selected. Different rotations may provide slightly different results but the differences are not dramatic; this was the case in the present study as very similar results were found when comparing quartimax to promax and to varimax rotations. Only quartimax rotation results are presented.

To identify the factor structure of the TPB, a principal component factor analysis with quartimax rotation was conducted on the 10 questionnaire items. Since for samples with less of 60 participants, items only can be acceptable if communalities account at least .60 (Martinez and Ferreira, 2008). The items "I want that Smartmoov' help me to reduce my mobility environmental impacts" and "I like to use the PT on my most frequent trip " were removed.

In the second analysis, sampling adequacy (Kaiser_meyer_olkin) indicates a mediocre compact of correlations (.608) and the analysis of sphericity indicates a strong relationship between the items (df = 28, $p < .001$), both of which show that factor analysis is appropriate for this measure. Factors were extracted on the basis of eigenvalue greater than 1, scree testing Figure 41, proportion of variance accounted, percentage of variance accounted, percentage of variance explained by each factor, number of items with significant factor loadings and factor interpretability (Kahn, 2006).

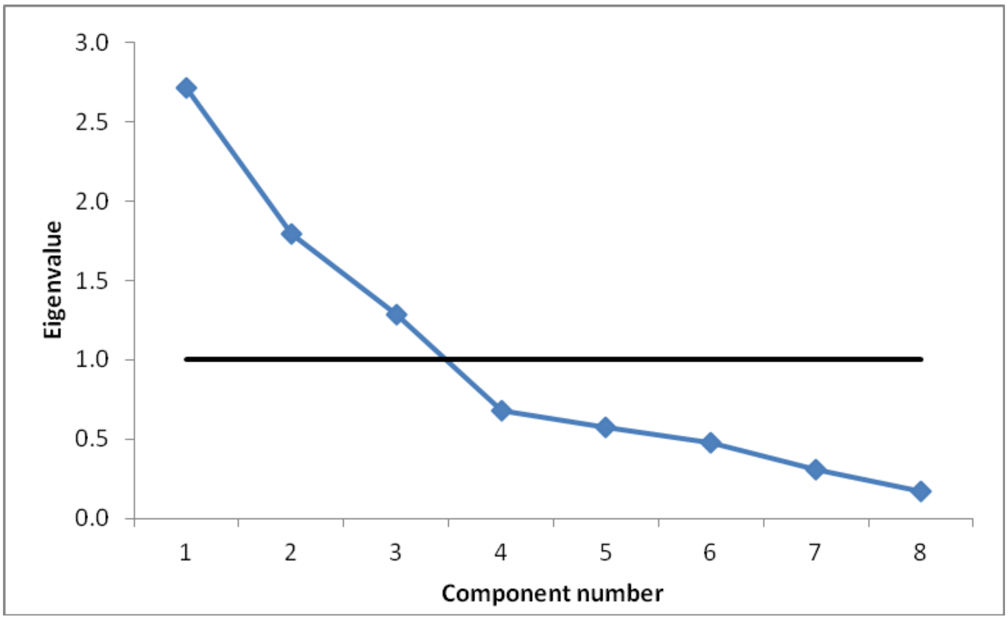


Figure 41 – Scree plot for Factor analysis of the 8 items from TPB

Considering all the above criteria, the best solution found was related to three main factors, accounting for 72.422% of the variance (Table 27).

Table 27 – Rotated Principal Components Analysis (PCA) Structure Matrix

Items	Construction	Factor 1	Factor 2	Factor 3
I expect that my family and friends put me under pressure to reduce the environmental impacts of my travels	SN	**.898**		
I expect that my family and friends incite me use Smartmoov'	SN	**.762**		
I expect that policy makers incite me use Smartmoov'	SN	**.754**		
I expect that policy makers put pressure on me to limit the environmental impacts of my travels	SN	**.753**		*.346*
I don't love driving for most frequent trip	ATT		**.883**	
I don't like to travel by car	ATT		**.882**	
I would use the PT more often if I had real-time information	PBC			**.809**
I would use more the velov' if the real-time was available	PBC			**.784**
Eigenvalues		2.713	1.795	1.286
Percentage variance explained		33.908	22.436	16.078

Note: All factor loadings > .300 (or<-.300) are shown. Loadings of items used to identify each factor are in bold; other loadings are italicized. SN = subjective norms; ATT = attitudes towards the behaviour; PBC = perceived behavioural control.

The PCA gave a three-factosr dimension, matching the proposal of theory of planned behaviour. Table 27 shows the rotated matrix and includes all loadings >.300 (or<-.300). Loadings of the items used to identify each factor are in bold other loadings are in italics. Factors were identified as representing attitudes towards the behaviour (ATT), perceived behavioural control (PBC) and subjective norms (SN). Eigenvalues for these factors were 2.713 (SN), 1.795 (ATT) and 1.286 (PBC), all above the threshold of 1 for factor retention (Kaiser, 1974). The three factors explained 33.908%, 22.436% and 16.078% of variance in the set of items and explained a total of 72.422% of the variability of the original eight variables. Therefore, we can considerably reduce the complexity of the data set by using these components, with 27.578% loss of information.

All items presented at least .60 of communality. Mean communalities value was .724 over threshold of .700. Finally, all items presented a loading factor above .600 (Budaev, 2010).

Cronbach's α was computed for the items used in identifying each factor: SN, α = .802; ATT, α = .739; PBC, α = .532. Values for all scales except perceived behavioural control reached the .700 threshold. Despite the PCB construct showed a poor value for internal consistency, but still acceptable, it was decided to use this PBC construct in the analysis because small samples size can deflate the Cronbach's α value (Cortina, 1993). Respondents' scores on reliable scales were computed by taking their mean on items comprising each scale, so that scores ranged from 1 to

5 (Table 28). For all TPB constructs the 50 participants, in mean values, scored near the middle point of the scale.

Table 28 – Factor Descriptive Statistics

Factor	Mean	S.D.	Min	Max	Skewness	Kurtosis
PBC	3.030	1.193	1.00	5.00	-.196 (S.E. = .337)	-.917 (S.E = .662)
ATT	2.890	1.279	1.00	5.00	-.088 (S.E. = .337)	-.941 (S.E = .662)
SN	2.775	947	1.00	5.00	.208 (S.E. = .337)	-.028 (S.E = .662)

Pearson correlation and Spearman's rho did not show any significant correlation among the three constructs, therefore the constructs are independent.

TPB constructs and intention to change mobility habits

The intention to change transport mode was asked on 1 to 5 scale. Answers 1 and 2 mean that they do not want to change mobility habits. Answer 4 and 5 mean that they intend to change mobility pattern. Answers on the middle point (3) were excluded because were undecided people. Table 29 shows descriptive statistics for people who express the intention to maintain or change their transport habits (hereafter, "maintainers" and "changers"). Higher values in the SN and PBC construct by the changers are coherent with the theory. However, the higher mean value in the ATT construct by the maintainers' is quite unexpected.

Table 29 – Descriptive statistics for theory of planned behaviour variables for different intentions

Intention	Constructs	Mean	Min	Max	SD	Variance	n
Maintain transport habits	ATT	3.259	1.00	5.00	1.259	1.584	27
	SN	2.704	1.00	5.00	1.070	1.144	27
	PBC	2.685	1.00	5.00	1.257	1.580	27
Change transport habits	ATT	2.0000	1.00	4.50	1.275	1.625	9
	SN	2.7500	1.75	4.00	.791	.625	9
	PBC	3.2778	1.50	4.00	.833	.694	9

Mann-Whitney tests showed no significant differences between maintainers' and changers' on SN (U = 121, p = .985) and PBC (U = 82.5, p = .149), but there is significant differences (p < .05) for ATT (U = 56, p = .016). Changers had lowers attitudes toward change transport mode.

Spearman's rho (ρ) correlations among variables were calculated and the three construct had not significant correlation among them. This indicated that multicollinearity would not be a problem in regressions using these variables as predictors (Field, 2000).

A logistic regression was used to understand the ability of the TPB model to explain the modal change intention. In this TPB regression, subjective norms, attitudes and both perceived behavioural control items were entered simultaneously. Table 30 shows the regression outputs.

Table 30 – Theory of Planned Behaviour regression Model

Predictor	Coefficient	SE	Coef/S.E.	*p-value*	Exp(coef)
SN	-.098	.546	-.179	.858	.907
ATT	1.100	.433	2.54	.000*	3.01
PBC	-1.021	.549	-1.86	.032*	.360
Constant	1.597	2.19	.730	.466	4.94

Note: * sig. at .05

In this regression, ATT and PBC constructs were significant ($p < .05$) and SN construct was not. As follow-up it was built a model using forward stepwise method. Attitudes towards behaviour (ATT) was added to the model (Table 31). Subjective norms (SN) was left out of the analysis at the first step because had significance values larger than .05. However, even though, perceived control behaviour (PCB) had a significant value, it was left out on the last step because it did not contribute to better fit the model. For a logistic model, if the intercept is zero (equivalent to having no intercept in the model), the resulting model implies that logit (or log odds) is zero, which implies that the event probability is .5. This is a very strong assumption that sometimes is reasonable, but more often it is not. Therefore, a highly significant intercept in this model is generally not a problem (SAS, 2013).

Table 31 – Final Model

Predictor	Coefficient	SE	Coef/S.E.	*p-value*	Exp(coef)	95% CI Exp(coef)	
						Lower bd	upper bd
ATT	.835	.373	2.24	.043	2.31	1.08	4.92
Constant	-1.068	.954	-1.12	.302	.344	.050	3.29

Note: * sig. at .05

As a further check, the backward stepwise method was used. The two methods choose the same variable, Attitudes towards behaviour (ATT), so we can be fairly confident that it's a good model.

To understand better whether the model adequately describes the data, it was calculated the Hosmer-Lemeshow test and the C.C. Brown test. These statistics indicate a poor fit if the significance value is less than .05. Looking at Table 32 it can be observed that the model adequately fits the data.

Table 32 – Goodness-of-fit Test

Test	Chi-square	df	Sig.
Hosmer and Lemeshow	7.411	7	.387
C. C. Brown	.851	2	.653

The model is reported in the equation2:

$$Pr[\mathit{Maintain}] = \frac{e^{-1.068+.835ATT}}{1+e^{-1.068+.835ATT}} \qquad [1]$$

Where the odds of maintain the mode use increase by a multiplicative factor of 2.31 (Exp(a) = .835) for each absolute increment on the ATT score.

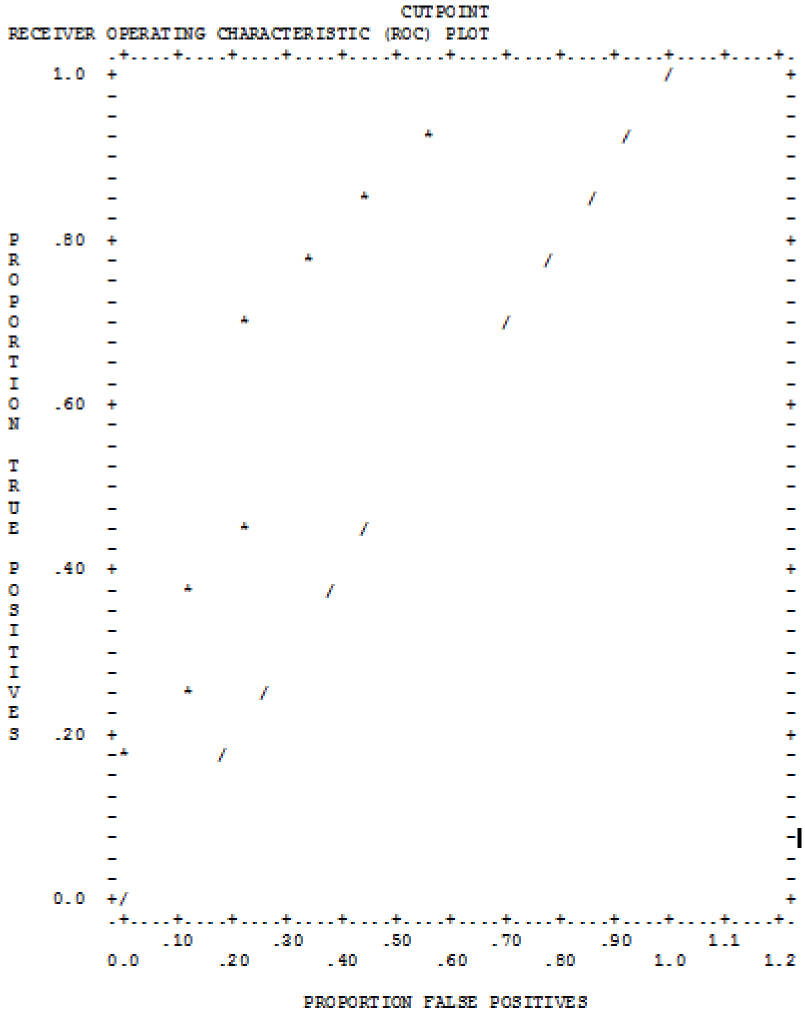
Table 33 shows the results of logistic regression model. Using the default threshold, BMDP will classify a subject into "Changers" category if the estimated probability is .5 or more. On the other hand, the BMDP will classify a subject into the "Maintainers" category if the estimated probability is less than .5. Cells on the diagonal are correct predictions and cells off the diagonal are incorrect predictions. Overall, 80.6% of the cases are correctly classified.

Table 33 – TPB Logistic regression model classification table

	Predicted		
Observed	Maintain	Change	Percentage Correct
Maintain	25	2	92.6
Change	5	4	44.4
	Overall Percentage		80.6

The ROC curve (Figure 42) is a visual index of the accuracy of the predicted values and more the curve lies above the reference line, more accurate the test is. The area under the curve represents the probability that the predicted result for a randomly chosen positive case will exceed the result for a randomly chosen negative case. In this model the area is .770, being better our model than a randomly guess.

Figure 42 – Behaviour model ROC curve



TPB constructs and most frequent mode used

A Mann-Whitney test showed significant differences ($p < .05$) between ATT ($U = 58$, $p < .001$), and PBC ($U = 178$, $p = .009$), but there is no significant difference as regards SN ($U = 258$, $p = .294$). Sustainable commuters scored significantly higher on ATT and PBC than polluters (Table 34).

Table 34 –Descriptive Statistics on TPB and most frequent mode

Mode	Construct	Mean	S.D.	Min	Max	N
Pollutant	PBC	2.673	1.086	1.00	5.00	26
	ATT	2.000	.8246	1.00	3.00	26
	SN	2.885	.852	1.25	5.00	26
Sustainable	PBC	3.417	1.204	1.00	5.00	24
	ATT	3.854	.938	2.00	5.00	24
	SN	2.656	1.045	1.00	5.00	24

Figure 43 shows the above finding. Polluters, in blue, are mainly scored in the down left quadrant; they have negative attitudes towards the performance of the behaviour and negative perceived control to perform the behaviour. On the opposite side, the majority of the sustainable commuters, in green, scored on the upper right quadrant, and they have a positive attitude towards the change of mode, as well as a high perceived control behaviour.

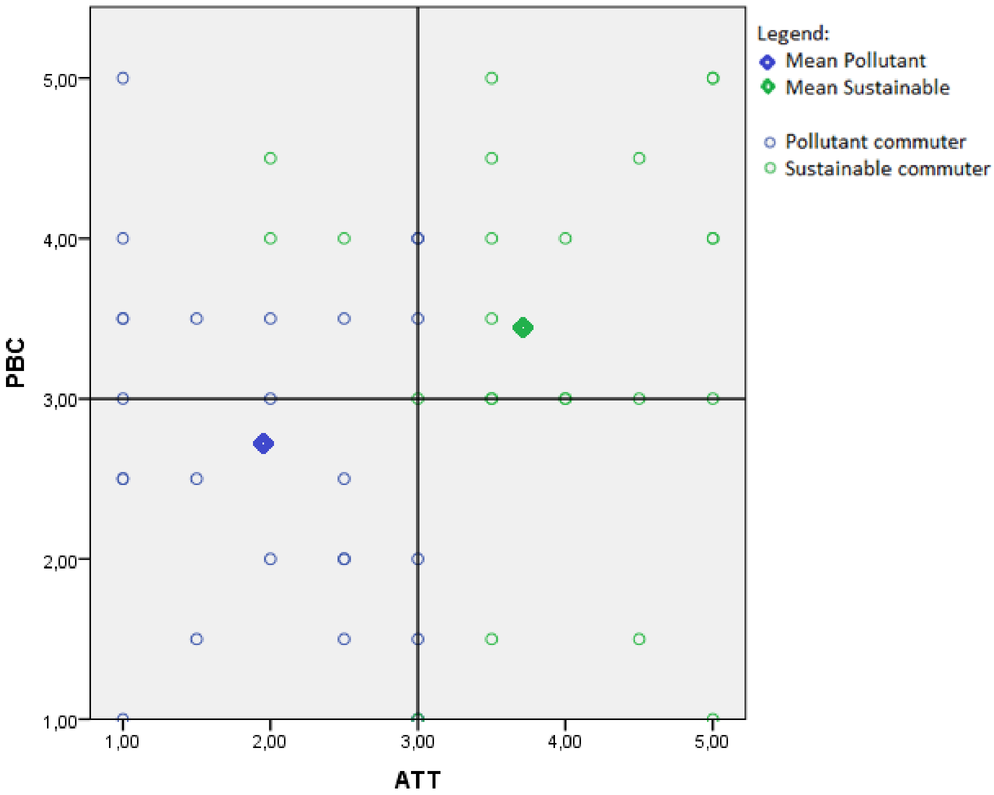


Figure 43 – PCB and ATT by most frequent mode used

TPB constructs and intention to change towards a sustainable mobility

Multimodal information systems were design to promote mobility efficiency contributing to the modal shift, from cars to bikes and/or public transport. Narrowing down the research to the polluters the influence that the TPB constructs have on the intention to change or maintain the use of the pollutant mode was study. Higher values of the changers in the SN and PBC construct are coherent with the theory. However, the higher mean value in the ATT construct by the maintainers is quite unexpected (Table 35). Mann-Whitney test showed significant differences ($p < .05$) between ATT ($U = 13.5$, $p = .003$) and PBC ($U = 8.5$, $p = .009$), but there is no significant differences regarding SN ($U = 31.5$, $p = .669$).

Table 35 - TPB constructs of the intention of the polluters

Intention	Constructs	Mean	Min	Max	SD	Variance	n
Maintain pollutant	ATT	2.2083	1.00	3.00	.81068	.657	12
	SN	2.7708	1.25	4.00	.84919	.721	12
	PBC	2.0417	1.00	4.00	.91598	.839	12
Change mode	ATT	1.3333	1.00	2.50	.60553	.367	6
	SN	3.0417	2.25	4.00	.79713	.635	6
	PBC	3.3333	2.50	4.00	.51640	.267	6

All the values of TPB constructs values are low nevertheless, the changers score on attitudes towards behaviour (ATT) is astonish. Indeed, this very low value could mean that the express intention to change will not immediate antecedent of the behaviour.

2. Results of Study 2 – Effects of Smartmoov'

The results presented in this section are based on the first analysis carried out to study the normality of each variable. The details can be read in the appendix IV.

Sample description

This study involved 46 persons, out of the 50 selected at the begginig. Four participants abandoned the experimentation.

The reduced sample maintains the balance between genders, 23 males and 23 females. The ages range from 23 to 68 and are similar in both genders (Figure 44). There is not any significant difference between the ages of male and female population ($t(44) = .723$, $p = .474$) and the mean age of the sample is 43.04 years old (SD = 12.18).

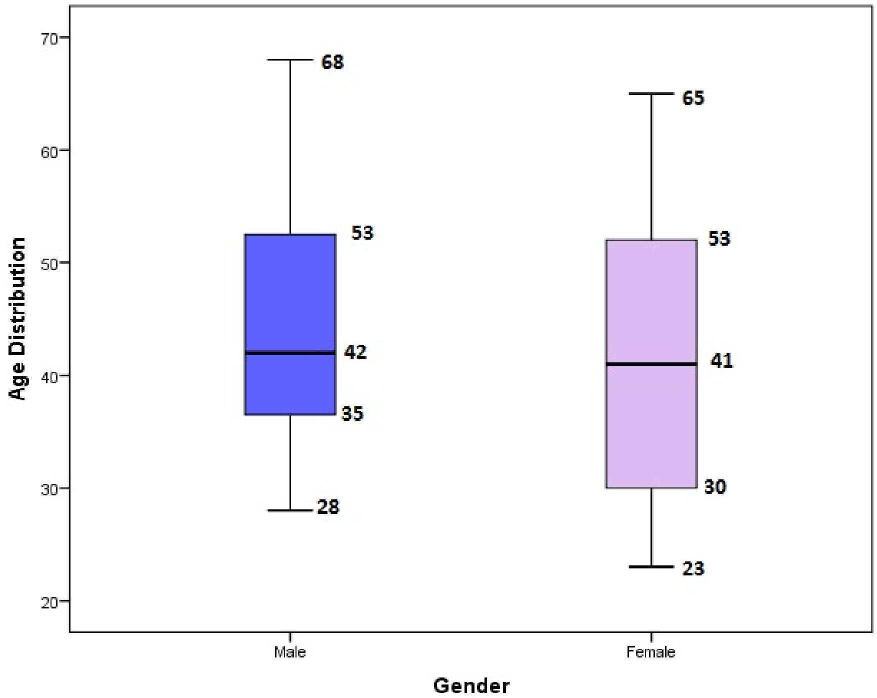


Figure 44 - Age distribution by gender Study 2

Figure 45 shows that 17 respondents got a higher education degree (17 "Bac +4 et plus"). On the other hand, 29 respondents have not attended university and two of them do not have any diploma.

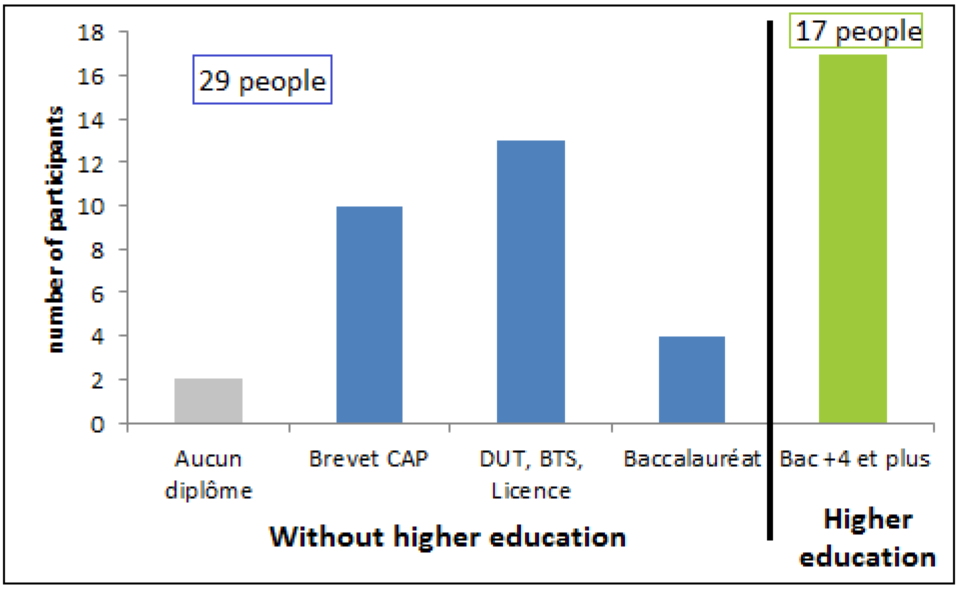


Figure 45 – Education

The respondents presents the follow distribution related to the household size: 12 live alone, 14 live with one other person, 7 live with more two people and 14 live with 3 or more people. As expected, the number of children in the household have a strong significant positive correlation with household size (r = 0,889, p <.001). There are 25 households without children and 21 having children (7 with one kid, 11 with 2 kids, 2 with 3 kids and 1 with 4 kids). The age of the children varies from 2 to 20 years-old. The mean age of the youngest child is 8.29 (SD = 5.61).

Forty-two participants have at least one car available in the household (26 household with one car; 16 with 2 cars; 2 with 3 or more cars) and only four participants did not get driving license. There is not any significant correlation between the household size and the number of available cars (r = .261, p = .080).

Seventy participants own a PT pass: 8 have an annual pass and 9 a monthly pass. Only 5 people own the Velo'v pass.

About the wages: only 4 people gain less than 1500 euro/month; 22 get between 1500-3000 euro/month; 11 between 3000-5000 euro/month; 4 people more than 5000 euro/month.

There are two persons who changed home, eleven changed destination and two people who changed both home and destination during the experimentation period.

2.1. Changes occurred after the experimentation of Smartmoov'

Expected and actual outcomes

In the ex_ante questionnaire 19 people agreed that the use of the Smartmoov' would be a facilitator towards a change of travel behaviour. In the ex-post questionnaire, only 3 people agreed that it was actually a facilitator for their behavioural change. There is a considerable and significant effect on the answers due to the experimentation. Comparing the questionnaires

{Paired t-test: $t(45) = 3.64$, $p < .001$, 95% CI [. 340, 1.181]; Wilcoxon Signed Ranks Test: Z = -5.347, p <. 001} the mean value passed from neutral ($M = 3.35$, $SD = .849$) to disagree ($M = 1.98$, $SD = 1.022$). Thus, after the experimentation people are do not think that Smartmoov' is a real facilitator towards a change of travellers' behaviour.

Similarly, when asked if Smartmoov' would be an incentive for changing travel behaviour in the ex_ante questionnaire 15 people agreed within the ex_post only 9 people agreed. Again, there is a significant effect of the experimentation on the answers between the two questionnaires {Paired t-test: $t(45) = 9.117$, $p <.001$, 95% CI [1.067, 1.672]; Wilcoxon Signed Ranks Test: Z = -3.20, p <.001} where the mean value passed from neutral ($M = 3.04$, $SD = 1.173$) to disagree ($M = 2.28$, $SD = 1.277$). This fact shows that after the Smartmoov' experimentation the participants disagree that this app is an incentive to change their behaviour.

Travel time-saving is one of the main features of the Smartmoov' app. When asked, in the ex_ante survey, if they expected to gain time using it, almost all the participants (42) agreed. On the contrary, in the ex_post survey only one third of the participants (14 people) declared that had gained time using Smartmoov'. Once more there is a significant difference between the responses before and after the experimentation {Paired t-test: $t(45) = 6.84$, $p <.001$, 95% CI [1.05, 1.94]; Wilcoxon Signed Ranks Test: Z = -4.893, p <.001} where the mean value passed from agree ($M = 4.42$, $SD = .581$) to neutral ($M = 2.61$, $SD = 1.355$). So, it has to be assumed that the real gain of time using the Smartmoov' did not match the expectations of the participants.

In the ex_ante survey there were three questions that assessed Smartmoov' influence on limiting travel environment impacts. These statements were: "I expect that Smartmoov' helps me to reduce the environmental impacts of my travels"; "I want the Smartmoov' helps me to reduce the environmental impacts of my travels"; and, "I intend to decrease the environmental impact of my travels through the use of Smartmoov'". These three questions showed an excellent alpha of Cronbach's Alpha (α = .911) so that their mean value produced a new variable. Consequently, in the ex_ante questionnaire, 29 participants declared that Smartmoov' would help to decrease their environmental impacts. After the experimentation only 6 participants revealed that the Smartmoov' app helped to decrease their environmental impacts. These changes are statistically significant showing that there is a big difference between the answers of the two questionnaires {Paired t-test: $t(45) = 8.42$, $p <.001$, 95% CI [1.19, 1.94] Wilcoxon Signed Ranks Test: $z = -5{,}374$, $p <.001$} passing from an agreement perspective on the ex_ante ($M = 3.76$, $SD = 1.046$) to a disagreement on the ex_post ($M = 2.20$, $SD = 1.276$).

The Table 36 summarises the participant's agreement according to the previous statements.

Table 36 – Agreement related to the expectations and the revealed behaviour induced by Smartmoov' app

Participants claim to believe that…	Ex_ante	Participants report that…	Ex_post
SMARTMOOV' will be a facilitator towards a change in my mobility behaviour	19	SMARTMOOV' has facilitated a change in my mobility behaviour	3
I feel an incentive to change my mobility behaviour due to the use of SMARTMOOV '	17	I felt an incentive to change my mobility behaviour due to the use of SMARTMOOV'	9
I expect to gain time, thanks to SMARTMOOV '	42	I gained time, thanks to SMARTMOOV '	14
The mean value of three statements related to limit the environmental impact of mobility associated with the use of SMARTMOOV'	29	SMARTMOOV' has helped me to reduce the environmental impact of my travels	6

Traveller intentions

The Table 37 summarizes the participants' agreement with intention statements showing the differences between the ex_ante and ex_post questionnaires.

Table 37 – Agree with intention statements

Agreed that…	ex-ante survey	ex_post survey
I intend to change my travel habits	8	3
I would use the TC more often if I had real-time information on timetables and passes	24	16
I would use Vélo'v more often if I had real-time information on the availability of Vélo'v and occupation sites	13	10
I would use my car more often if I had real-time traffic information	16	4
I would carpool more often if I had real-time information on the its availability	18	14

It is possible to see that the number of participants agreeing with the statements decreased from ex-ante to the ex-post survey. Table 38 study the statistical significance of these differences.

Table 38 – Intention statements statistical differences introduce by the experimentation

Statements	Paired T-test	p-value	Wilcoxon Test	p-value
I intend to change my travel habits	2.003	.051	1.86	.068
I would use the PT more often if I had real-time information on timetables and passes	1.772	.083	-1.741	.082
I would use Vélo'v more often if I had real-time information on the availability of Vélo'v and occupation sites	N/A	N/A	-1.741	.082
I would use my car more often if I had real-time traffic information	N/A	N/A	-2.546	.011*
I would carpool more often if I had real-time information on the its availability	N/A	N/A	-1.210	.226

* significant at the 0.05 level.

Beside of the differences observed at the Table 37, for all statements, the only significant difference introduce by the experimentation was about the presence of real-time information increased the use of the car (Table 38). In fact, as showed in the Table 39, the answers on the ex_post are shift towards the disagreement. The number of participants that agreed had a substantial decrease between the two questionnaires from 16 people in ex_ante to only 4 in the ex_post survey.

Table 39 – Traffic real time information increase the car use percentiles

Variables	Percentiles		
	25th	50th (Median)	75th
Ex_ante	1,00	2,00	4,00
Ex_post	1,00	2,00	3,00

In Table 40 it is possible to see that before Smartmoov' experimentation the mode more "loved for the most frequent travel" was the PT. PT lost this position to the car after the experimentation; in effect the only mode that showed a substantial increase was the car with 6 more people agreeing that they love to drive for their most frequent travel.

Table 40 – Agreement with the mode preference to realize the most frequent travel

Agreed that on the most frequent travel…	ex-ante survey	ex_post survey
I love driving	12	18
I love riding PT	14	12
I love cycling	5	6
I love walking	11	9
I love carpooling	8	8

The Table 41 show the statistical significance of aforementioned differences.

Table 41 – Mode preferences statistical differences introduce by the experimentation

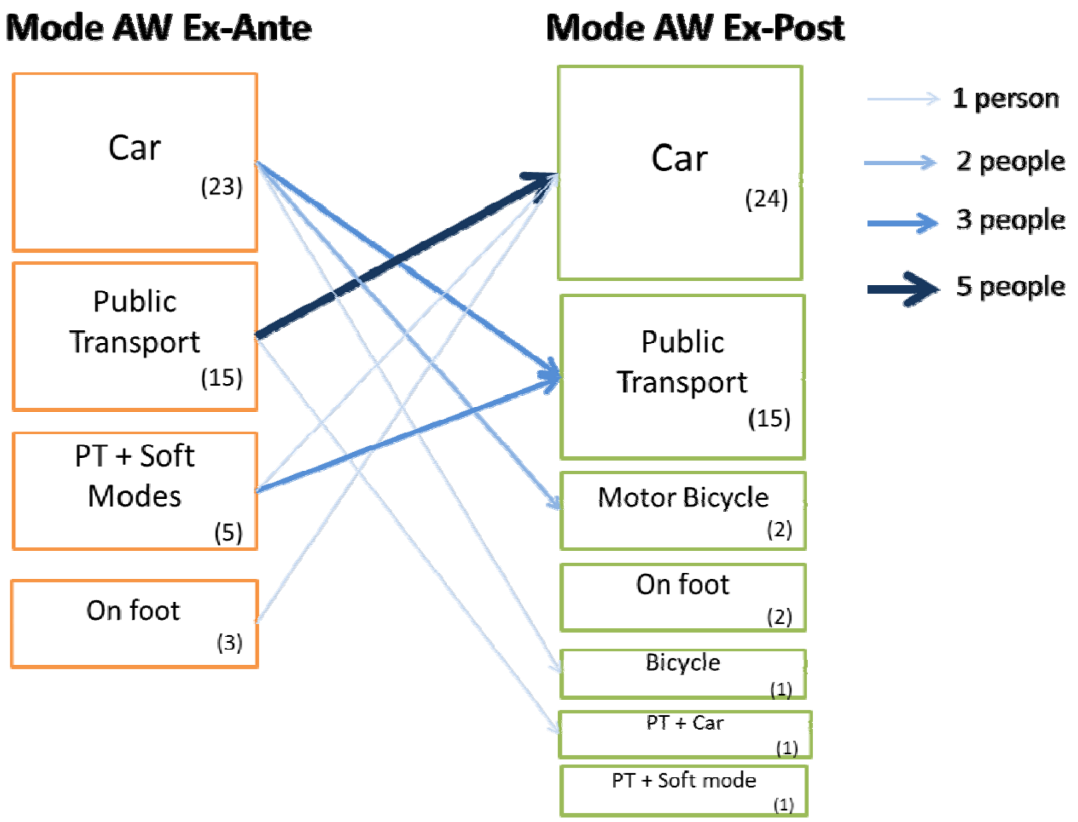
Statements	Paired T-test	p-value	Wilcoxon Test	p-value
I love driving	N/A	N/A	-1,277	.202
I love riding PT	.724	.473	-.564	.573
I love cycling	N/A	N/A	-. 455	.649
I love walking	.589	.559	-.344	.731
I love carpooling	.545	.589	-.554	.580

None of the statements showed significant differences comparing before and after experimentation. Participants showed the same neutral position throughout the experimentation about as regard their pleasure for driving for their most frequent travel. The same situation is observed for the statement "I love riding PT for the most frequent trip", that showed a mean value in the ex_ante survey (M = 2.76, SD = 1.493) almost identical to the mean value in the ex_post survey (*M* = 2.63, *SD* = 1.466), both on neutral point of the scale. In mean values, participants never liked to use the bike during the most frequent travel. Besides not being statistically significant the statement "I like to walk on foot for my most frequent travel" showed a small change from a neutral position on the ex_ante survey [*M* = 2.59, *SD* = 1.392] to a disagreement position on the ex_post survey [*M* = 2.48, *SD* = 1.346]. Participants pleasure to carpool on their most frequent travel participants did not changed opinion after the experimentation disagreeing on both questionnaires ex_ante [*M* = 2.28, *SD* = 1.259] and ex_post [*M* = 2.39, *SD* = 1.291].

Effects on travel behaviour

The main scope of the introduction of a multimodal information system is to produce a modal shift on its users (Simonelli and Bifulco, 2005).

Regarding the most frequent travel, in general terms, no global changes towards sustainable mobility occurred in the Autumn/Winter period. In fact, as observed in Figure 46, some participants moved from car to other modes and other participants from more sustainable modes to car. In contradiction with the theoretical expectations, the number of car users has slightly grown after the experimentation, passing from 23 to 24.



AW - Autumn Winter; **PT** - Public Transport

Figure 46 – Mode changes on Autumn/winter

In synthesis, during the Autumn/Winter period, before the experimentation 23 people used a pollutant mode (Car) while after the experimentation this figure raised to 26 people (car or motorcycles) for their most frequent trip.

During the Spring/Summer period the same pattern was observed, without substantial changes. There is more cars circulating (16 Cars before, 17 Cars after), 2 PT less (11 before, 9 after), one more bicycle (5 before, 6 after), one person walking less (5 before, 4 after), one person riding PT+softmodes less (3 before, 2 after), 3 people using PT+auto more (3 before, 6 after) and one more using motorcycle (2 before, 3 after).

During the Spring/Summer time is possible to observe a slight increase in the use of polluting modes from 18 people (Car + moto) to 20 people (Car + moto).

Comparing the use of the **Car** on the ex_ante and on the ex_post it is possible to state that Smartmoov' did not produce any significant changes in the use of this mode (Table 42).

Table 42 – Car use statistical differences introduce by the experimentation

Car use on…	Wilcoxon Test	p-value
Winter/Autumn	.426	.670
Spring/Summer	-.610	.542
Weekends	-.832	.405

Similarly, when comparing the use of the **Motorcycle** between the two surveys it is possible to state that the introduction of the Smartmoov' did not produce any significant change in the use of such mode (Table 47).

Table 43 – Motorcycle use statistical differences introduce by the experimentation

Motorcycle use on…	Wilcoxon Test	p-value
Winter/Autumn	-1.187	.235
Spring/Summer	-.115	.909
Weekends	-.816	.414

Also, when comparing the use of the **PT** for the Autumn/Winter and Spring/Summer season it is possible to state that the introduction of the Smartmoov' did not produce any change in the use of this mode. Nevertheless, during weekends the answer before and after shows significant, but weak median difference (Table 44).

Table 44 – PT use statistical differences introduce by the experimentation

PT use on…	Wilcoxon Test	p-value
Winter/Autumn	-1.604	.109
Spring/Summer	-1.342	.180
Weekends	-2.194	.028*

* significant at the 0.05 level

Observing the Figure 47 is possible to identify a decrease of the public transport use after the introduction of the Smartmoov'.

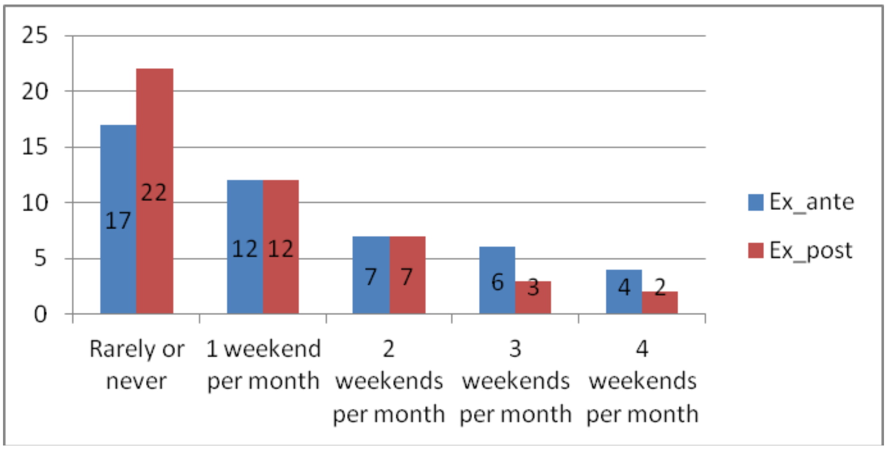


Figure 47 – Public transport use during the weekends

Comparing the **walking,** between ex_ante and ex_post surveys, during the Autumn/Winter and Spring/Summer significant median changes were observed. During the weekends the experimentation did not reveald significant differences (Table 45).

Table 45 – Walking use statistical differences introduce by the experimentation

PT use on...	Paired T-test	p-value	Wilcoxon Test	p-value
Winter/Autumn	N/A	N/A	2.543	.011*
Spring/Summer	N/A	N/A	-2.614	.009*
Weekends	.693	.492	-.818	.413

* significant at the 0.05 level

Figure 48 shows that more people used this mode after the experimentation (1, 2, 3 and 4 times a week) and the "never" score decreased. However, it is not possible to assume that these changes are entirely related to the introduction of the app.

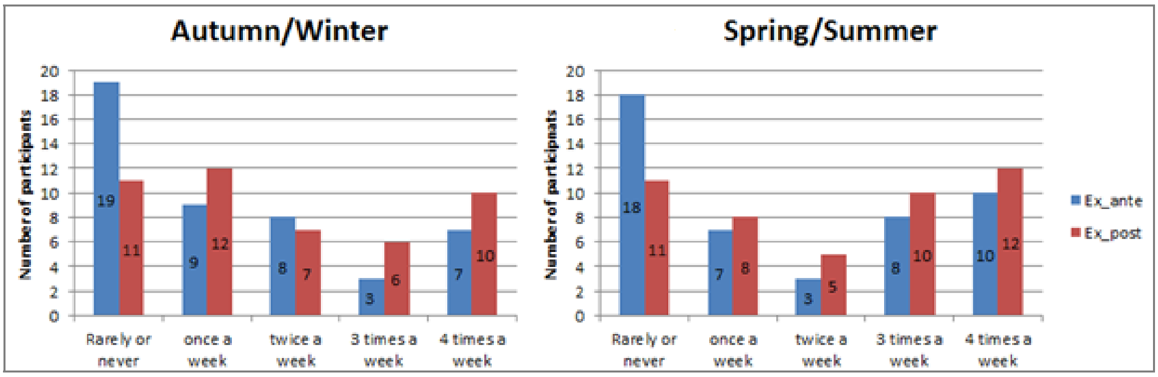


Figure 48 – Walking during Autumn/Winter and Spring/Summer periods

Comparing the use of **Bicycle**, **Velov'v**, **TER** and **Trotinette** in the ex_ante and in the ex_post survey during the Autumn/Winter, Spring/Summer and weekends it is possible to state that Smartmoov' did not produce significant changes in the use of these mode (Table 46).

Table 46 – Bicycle, Velov'v, TER and Trotinette use statistical differences introduce by the experimentation

Mode	Used on..	Wilcoxon Test	p-value
Bicycle	Winter/Autumn	1.218	.223
	Spring/Summer	-.182	.856
	Weekends	-.110	.912
Velov'v	Winter/Autumn	1.000	.317
	Spring/Summer	-.182	.856
	Weekends	-.707	.480
TER	Winter/Autumn	.577	.564
	Spring/Summer	-.577	.564
	Weekends	1.000	.317
Trotinette	Winter/Autumn	-.816	.414
	Spring/Summer	-1.000	.317
	Weekends	-1.633	.102

Smartmoov' Use

Looking at the Table 47, the number of people that reported the use of Smartmoov' to plan their trips after the experimentation was substantial lower than the express intention to use it before the experimentation.

Table 47 - Agreement with Smartmoov' use statements

Participants claim that...	N	**Participants report that...**	N
Intend to use SMARTMOOV' to plan occasional trips	45	Used SMARTMOOV 'plan for occasional trips	28
Intend to use SMARTMOOV' to plan daily commute	39	Used SMARTMOOV' to plan my daily commute	21
		Used SMARTMOOV' daily	12

In fact, the use Smartmoov' to plan occasional and daily trips showed significant changes after the experimentation (Table 48).

Table 48 – Smartmoov' use statements statistic test

Statements	**ex_ante survey**		**ex_post survey**		**Wilcoxon Test**	**p**
	Mean	**SD**	**Mean**	**SD**		
SMARTMOOV' to plan occasional trips	4.65	.526	3.67	1.136	-4.564	<.001*
SMARTMOOV' to plan daily commute	4.30	.785	3.37	.784	-4.347	<.001*

* significant at the 0.01 level

In general, participants agreed that they used the Smartmoov' to plan **occasional trips**, but significantly less stronger as regards the intention expresses. Indeed, the median score rating was 5.0 on the ex_ante survey and 4.0 on the ex_post survey.

For **daily trips** participants changed opinion from agreement a neutral position. This change is significantly different where the median value in the ex_ante was 4.0, agree position, and the report on the ex_post questionnaire where the median was 3.0, neutral point scale.

To understand better the use of the Smartmoov' on the daily base, on the ex_post survey, there was the statement: "I used Smartmoov' daily". The answers tend to show a neutral opinion (M = 2.89, SD = 1.080), with 17 people disagreed, 17 neutral and 12 agreed.

In the literature, three decision-making scenarios are reported where multimodal application (as Smartmoov') could be useful: Pre-trip planning, En-Route and Re-route. These scenarios were tested in the ex_post survey and the results are reported in the Figure 49. We can observe that the participants did not find useful using Smartmoov' for pre-trip planning and en-route information, while they considered it convenient for managing traffic problems and getting re-route information. The mean values support these findings (Table 49).

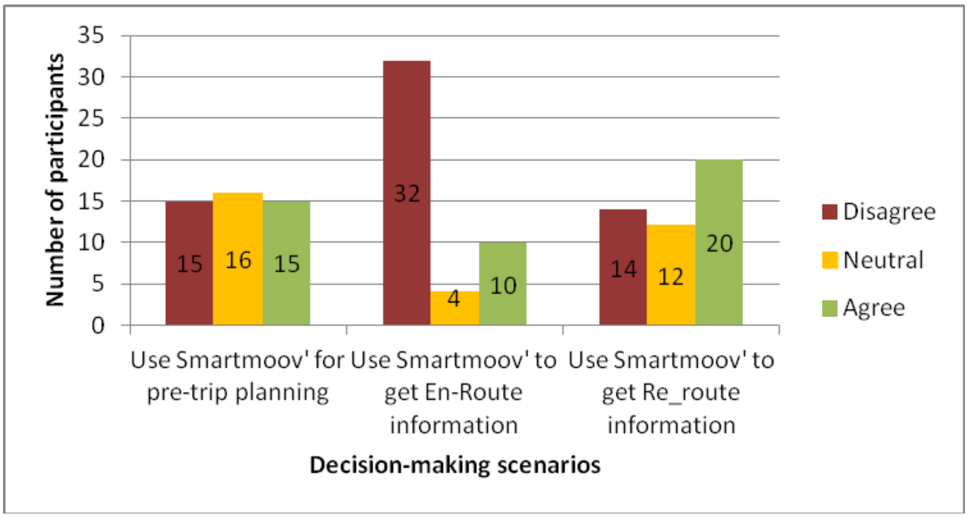


Figure 49 – Use of Smartmoov' app on the different decision-making scenarios

Table 49 – Smartmoov' use scenarios statistics

Statements	Mean	SD
Pre-Trip planning	3.07	1.18
En-route information	2.22	1.28
Re-route information	3.15	1.37

Another aspect analysed in the ex_post questionnaire was the usefulness of Smartmoov' in discovering new routes (Figure 50The mean answers show a neutral with negative outlook effect on discovering new routes (M = 2.93, SD = 1.526).

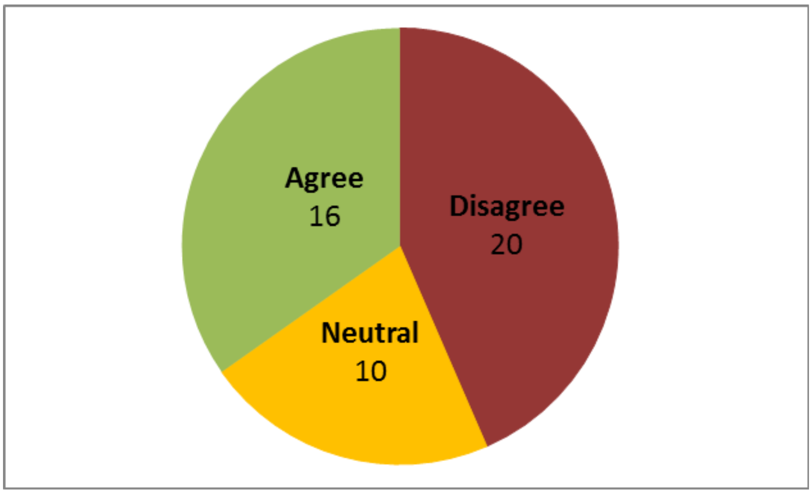


Figure 50 – Learn new routes using Smartmoves

Fourteen participants stated that Smartmoov' allowed them to save time during their travels and 16 assume that they found new routes using Smartmoov'. In fact, 11 of them agreed on both cases and these two variables are significantly positively correlated (R*s* = .652, *p* <.001). We can assume that participants saved time using Smartmoov' because they discoveredroutes that were unknown to them.

Willingness to pay

An important issue to understand the potential success of Smartmoov' is to assess the willingness to pay after the experimentation.

Figure 51 shows the willingness to pay has moved, even more, towards the left side of the graphic after the experimentation. This means that the willingness to pay after the experimentation is lower than previously note as showed by the Wilcoxon signed-rank test (*Z* = -2.062, *p* = .039). The median score rating has decreased from disagree scale point (2.0) to totally disagree scale point (1.0). We should be careful reading this analysis because we had no control group to compare these results.

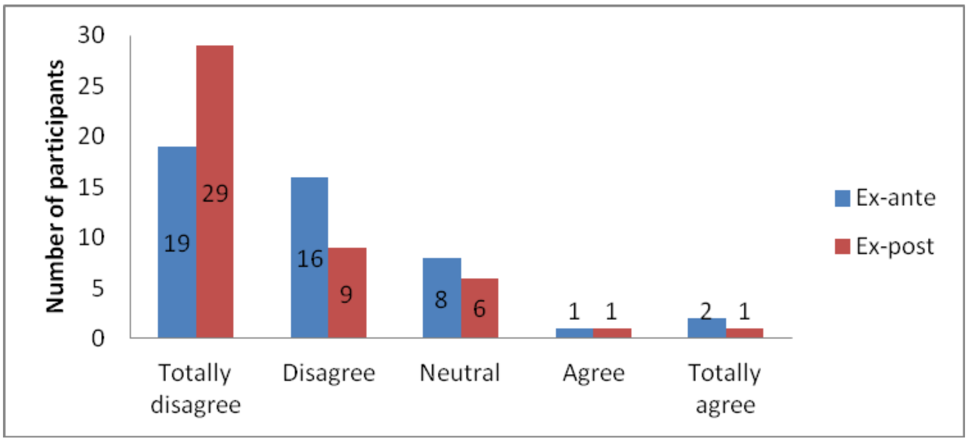


Figure 51 – Willingness to pay for Smartmoov'

Figure 52 reports the willingness to pay on a monthly basis before and after the experimentation.

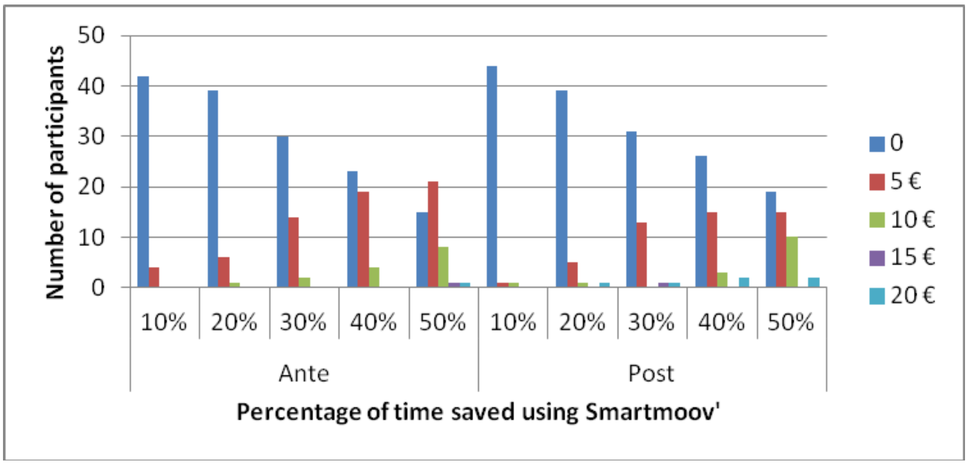


Figure 52 – Monthly Willingness to pay in function of the percentage of time saving using Smartmoov'

Table 50 a slight difference between ex_ante and ex_post, but not significant variations. It is interesting to observe how the willingness to pay for saving 10% or 50% is lower in the ex_post survey while the willingness to pay for saving 20%, 30% and 40% of time is higher.

Table 50 – Total monthly sum declare by the 46 participants

	10%	*20%*	*30%*	*40%*	*50%*
Ex_Ante	20 €	40 €	90 €	135 €	220 €
Ex_ Post	15 €	55 €	100 €	145 €	215 €

Figure 53 shows that less are willing to pay, but who intend to pay is willing to pay even more. In the ex_ante questionnaire the amount 5, 10, 15 and 20 euro received 81 ticks while on the other hand, on the ex_post questionnaire only 71. The overall amount of money passed from 505€ (ex_ante) to 530€ (ex_post), with a mean value of 6.23€ (ex_ante) and 7.46€ (ex_post).

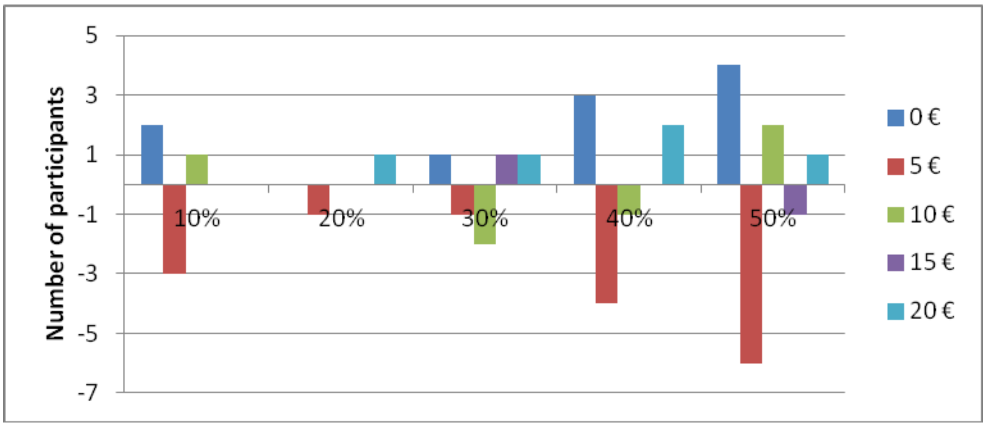


Figure 53 – Monthly differences between before and after willingness to pay as regards the time saved

Observing the annual values it is possible to see slight differences on the total amount of money before and after experimentation (Figure 54).

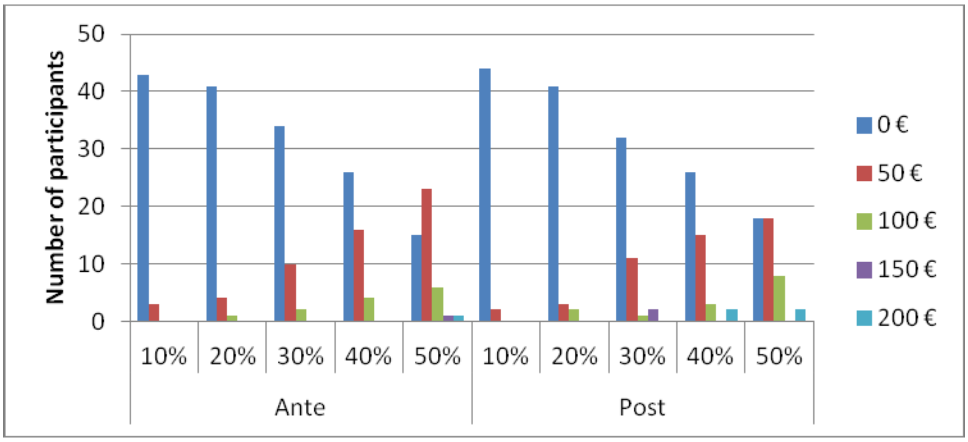


Figure 54 - Annual Willingness to pay in function of the percentage of time saving using Smartmoov"

Only the 10% saving of time shows a lower amount in the ex_post survey, while the amount of monay bigger or equal for all the other values (Table 51)

Table 51– Total sum declare by the 46 participants annually

	10%	*20%*	*30%*	*40%*	*50%*
Ex_Ante	150 €	300 €	700 €	1.200 €	2.100 €
Ex_ Post	100 €	350 €	950 €	1.450 €	2.100 €

Time the number of ticks decreased from 71 to 69, and the total amount of money has grown from 4.450€ to 4.950€.

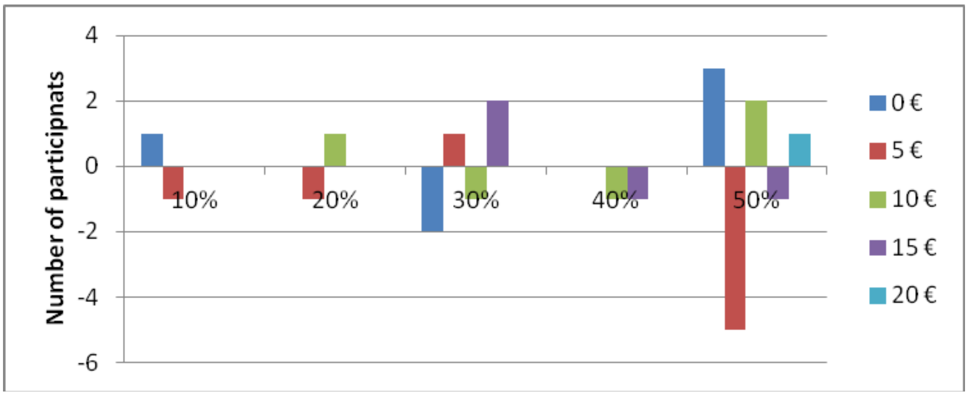


Figure 55 - Annual differences between before and after willingness to pay as regards the time saved

The comparison ex_ante and ex_post experimentation shows that there is a decrease in the number of people who admit that are willing to pay for using Smartmoov'. Even though, the monthly and annually amount of money that they like to spend has increased, suggesting that the people that are ready to pay after the experimentation also intends to pay more for its use comparing to what was declared in the ex_ante survey.

Ergonomics

The ergonomics is important for using Smartmoov, to this extend three statements were evaluated. Table 52 reports the differences on the agreement with the three statements before and after the experimentation. It is possible to see that all values are lower after the experimentation, meaning that people found a less easy to use app and had more problems to use Smartmoov' that expected.

Table 52 – Agreement with ergonomic statements

Participants claim that…	N	**Participants report that…**	N
Expect to have an easy to use app	38	SMARTMOOV' is an easy to use app	14
Don't think that will face different problems using SMARTMOOV' daily	15	Didn't faced different problems using SMARTMOOV 'daily	7
		Didn't lose time using SMARTMOOV'	21

In fact, after the experimentation the opinion of the participants significantly changed (Table 48).

Table 53 – Smartmoov' use statements statistic test

Statements	**ex_ante survey** **Median**	**ex_post survey** **Median**	**Wilcoxon Test**	**p**
Easy to use app	5	3	-4,682	<.001*
Not face different problems using SMARTMOOV' daily	3	2	-3,062	.002**

* significant at the 0.01 level
**significant at the 0.01 level

The statement "I didn't lose lots of time using Smartmoov'", was only present in the ex_post questionnaire. Almost half of participants (21) tend to agree that didn't lose time using Smartmoov', 15 are neutral and only 10 admit that they lost time using this app. It is not clear if the participants did not lose time because they did not use it or, on the contrary, they did not lose time because the app gave the information required in a fast and accurate way.

2.2. Behavioural constructs towards modal change

Theory of planned behaviour constructs modifications after experimentation

On the first study, a principal component analysis (PCA), using the statements on the ex_ante questionnaire, was used to identify the TPB constructs: attitudes towards behaviour (ATT), the perceived behaviour control (PCB) and the subjective mode (SN) (Table 54).

Table 54 – Items used to create the TPB constructs

Items	Construction
I expect that my family and friends put me under pressure to reduce the environmental impacts of my travels	SN
I expect that my family and friends incite me use Smartmoov'	SN
I expect that policy makers incite me use Smartmoov'	SN
I expect that policy makers put pressure on me to limit the environmental impacts of my travels	SN
I don't love driving for most frequent trip	ATT
I don't like to travel by car	ATT
I would use the PT more often if I had real-time information	PBC
I would use more the velov' if the real-time was available	PBC

In the ex_post questionnaire, the same statements were present. Afterwards the Cronbach's α was computed for the items used for each factor, to understand if this constructs still made sense for the sample of 46 participants (Table 55).

Table 55 – TPB constructs Cronbach alpha

	Cronbach's α	
Construct	**Ex_ante**	**Ex_post**
ATT	.719	.671
PBC	.520	.674
SN	.805	.745

Values ATT and SN in the ex_ante and SN in the ex_post reached the .700 threshold. Despite in the ex_ante the PCB construct showed a poor value for internal consistency (but still acceptable) it was decided to use this PBC construct on the analysis based on the fact that small sample size can deflate the Cronbach's α value. ATT and PCB constructs in the ex_post did not reach the threshold, but showed an acceptable value for internal consistency (Cortina, 1993). Participants' scores on reliable scales were computed by taking their mean on items included in each scale, so that scores ranged from 1 to 5.

Pair T-test and Wilcoxon Signed Ranks test were preformed to verify if there were significant differences on how participants scored the TPB constructs between the two questionnaires (Table 56).

Table 56 – TPB constructs values before and after experimentation

Construct	ex_ante survey		ex_post survey		Pair T-test	*p*	Wilcoxon Test	*p*
	Mean	**SD**	**Mean**	**SD**				
ATT	3.00	1.234	2.99	1.213	1.518	.136	-.500	.617
PBC	2.98	1.197	2.71	1.162	.068	.946	-1.315	.188
SN	2.82	.957	1.48	.673	N/A	N/A	-5.879	<001*

* significant at the 0.01 level

ATT and PBC showed no significant differences between questionnaires, remaining stable over time. On the contrary, SN construct presented a significant decrease between ex_ante survey (2.75) and ex_post survey (1.25).

Intentions after experimentation

Table 57 shows descriptive statistics for people who, after the experimentation, stated intentions to maintain or change their transport habits (hereafter, "maintainers" and "changers"). As the question about the intention to change transport habits was on 1 to 5 scale, the answers scored on the middle point (3) were excluded, so that we consider who answered 1 or 2 as "maintainers" and 4 or 5 as "changers".

Table 57 – TPB constructs after experimentation

Intention	**Constructs**	**Mean**	**Min**	**Max**	**SD**	**Variance**	**n**
Maintain transport habits	ATT	3.150	1.00	5.00	1.267	1.606	30
	SN	1.433	1.00	4.75	.737	.543	30
	PBC	2.533	1.00	5.00	1.272	1.620	30
Change transport habits	ATT	2.833	2.50	3.00	.289	.083	3
	SN	1.500	1.25	1.75	.250	.063	3
	PBC	3.333	2.50	4.00	.764	.583	3

Mann-Whitney tests showed no significant differences between "maintainers" and "changers" for all constructs after the experimentation SN (U = 30.5, p = .338), ATT (U = 37.5, p = .636) and PBC (U = 24, p = .184).

In the study 1, before experimentation, a model predicts the probability of maintain transport behaviour based on the TPB constructions was built [1].

$$\Pr[\mathit{Maintain}] = \frac{e^{-1.068+.888ATT}}{1+e^{-1.068+.888ATT}} \qquad [1]$$

This model showed that the attitudes towards behaviour increase the frequency of the intention to maintain the mode used. The model was applied also using the data of the ex_post survey to understand if it is valid also after the experimentation. The results show that this model still predicts 81.8% of the cases showing that the app did not alter how the constructs influence the intention (Table 58).

Table 58 - TPB Logistic regression model after the experimentation

	Predicted		
Observed	Maintain	Change	Percentage Correct
Maintain	27	3	90
Change	3	0	0
	Overall Percentage		81.8

The model is not capable to identify any of the "changers". This lack of fit of the model can be due mainly to the unbalance of the sample, 90% of the participants stated after the experimentation that they would maintain their transport behaviour.

Intention as behaviour predictor

The theory of planned behaviour states that volitional human behaviour is immediately preceded by intention to engage in this behaviour. Therefore, intentions to change behaviour before the experimentation were crossed with the observed behaviour for the most frequent mode after experimentation (Table 59).

Table 59 – Intention as behaviour predictor

Intention to change before the experimentation	Observed change of most frequent mode		
	No	Yes	Percentage Correct
Totally agree	2	1	33.3
Agree	3	2	40.0
Undecided	7	5	N/A
Disagree	9	4	69.2
Totally disagree	8	5	61.5
	Overall Percentage (without undecided)		58.8

The Table 59 shows that express intentions are not significant different comparing who change or maintained most frequent mode (U = 241.5, p = .906). In this case, expressing intention did not lead immediately to the behaviour; intentions were not a good predictor of actual behaviour.

Taking only in account pollutant commuters, before the experimentation, we observed that express intentions are not significant different comparing who change or maintained most frequent mode (U = 46, p = .716). Six participants shifted to a more sustainable mode, but only one had showed intention to do so before the experimentation, as Table 60 shows.

Table 60 – Intention as behaviour predictor towards sustainability

Intention to change before the experimentation	Observed change of most frequent mode		
	No	Yes	Percentage Correct
Totally agree	2	0	0
Agree	2	1	33.3
Undecided	5	2	N/A
Disagree	6	2	75.0
Totally disagree	2	1	66.6
	Overall Percentage (without the undecided)		56.2

Chapter VI – Discussion

The participants are familiar with the technology and already use Smartphones applications (e.g. googlemaps), GPS navigators and websites for getting travel information. This makes them close to the Smartmoov' concept.

Fayish and Jovanis (2004), already found that travellers demand ATIs that are user-friendly. Also in this research the participants declare that they expect that this app will be easy-to-use.

Participants agreed that real-time information about passes and schedules of PT will have a positive influence on their ridership, supporting the findings of Abdel-Aty (2001). Oppositely, participants disagree that having the real-time information in the car would increase car usage.

Grotenhuis et al. (2007) found that, for the use of multimodal ATIS, the most important feature is the time saving. The same applies for our sample who would like to use Smartmoov' if it helps to save time during their trips. Similarly, the feature of reducing environmental impacts of mobility was seen as an encouragement for the use of Smartmoov', even though less important as regards time saving.

Participants perceive that air and noise pollution, as well as traffic jams, are an issue in the area of Lyon. The large majority of the participants believe that a sustainable mobility would increase the quality of life. Such opinion was not translated in a pro-environmental intention, where only 6 out of the 26 commuters using pollutant modes intend to change habits towards a sustainable mobility. We can stand that modal shift towards a sustainable mobility is a typical environment value-action gap, meaning that there is a high awareness and knowledge of the problem, but relatively low level of intention to act (Kollmuss and Agyman, 2002).

However, differences among the users were found as regards the mode used, pollutant or sustainable. The participants who use pollutant modes give much more importance to factors as comfort, possibility of transporting people or objects and the need to use the car. Instead, the sustainable users rated as non-important the following reasons: safety from aggressions; unavailability of other modes of transport; possibility of transporting people or objects; and the need to use the car. Flexibility and independence are important reasons for both sustainable and pollutant groups, but they are statistically more important for pollutant riders.

The users of pollutant modes agree that their most frequent travel takes too long time, that it is too expensive and that it is a waste of time. They prefer make it by car, being faster, even if it causes stress; they disagree that they would not like to make this trip walking or by PT. On the other side, the users of sustainable modes prefer to travel more peacefully, even if it takes longer time. They do not consider the most frequent travel too expensive, they like to drive or carpool, they feel like wasting time when travelling by car, or TER or when riding a bicycle. The users of pollutant modes assess themselves more technologically competent than the users of sustainable modes. In one hand, users of pollutant modes showed that with real-time traffic information they would use more the car; instead the sustainable users disagree with this opinion. Contrariwise, the users of sustainable modes agree that they would use more the PT if they have real–time information about schedules and passes while the users of pollutant modes have an undecided position on this statement.

The majority of the participants showed curiosity to use Smartmoov', but they did not think that it could induce to change their travel habits. As expected, based on Bonsall and Joint (1991) findings, the participants intend to use the Smartmoov' app for occasional trips and are undecided if it would be useful for their daily trips.

Many studies (e.g. Hato et al., 1999; Khattak et al., 2003; Wolinetz et al., 2004) conclude that commuters are not willing to pay for the use of ATIS. In fact, our participants showed reluctance for paying to use Smartmoov'.

Definitely, the data analysis suggests that the economic success of the Smartmoov' app depends on the amount of time that it allows to save.

Effects on travel behaviour

Considering the same sample of 46 participants, before and after the five months of experimentation, it was found that Smartmoov' did not have any effect to favour the modal diversion of the participants. Only 3 out of the 8 participants having intention to change behaviour before experimentation, still want to change.

In fact, if before the experimentation of Smartmoov', the participants were undecided that this app could be a facilitator or an incentive for the modal shift, after the experimentation, it was clear that Smartmoov' did function neither as a facilitator nor as an incentive towards a more sustainable mobility.

Almost all the participants (42/46) thought that this app would help them to save time during their travels, but just less than one third (14/46) claimed that Smartmoov' truly helped them to save time. Therefore, it has to be assumed that the real saving of time using the Smartmoov' did not match the expectations of the participants.

The participants stated that this app did not help them to reduce their environmental impact as much as they supposed before using it.

This can be explained, to some extent, by the fact that the participants did not really need or did not have any intention to change travel behaviour. Due to this, the results show an opposite tendency as regards the initial intentions towards Smartmoov'.

Furthermore, the participants did not change intention about the use of the different modes thanks to the real-time information. Only a slight change was observed about the intention of using the car with access to real-time traffic information; in this case the participants changed from a neutral position to a disagreement position. Besides, not being statistically significant, it is important to refer that the number of participants that agreed that real-time information applied to PT would increase its use, have dramatically decreased, from 26 to 14. People, after the experimentation, realized that this kind of tools would not induce them use to more PT. These results confirm what already have been found for mono-modal real-time information that showed that the ATIS have a limited impact on PT mode use (Chorus et al., 2006; Holdsworth et al., 2007; Zhang et al., 2008).

The use of the car, bicycle, PT, walking and all other modes has not changed significantly during the weekdays and the weekends after the introduction of the Smartmoov'. It was observed a slight increase of the overall number of participants who used pollutant modes after the experimentation: 3 people more in Autumn/Winter and 2 people more in Spring/Summer used a pollutant mode for their most frequent trip.

Therefore, we can assume that Smartmoov' did not change the travel conditions and past travel choices had strongly contribute to explain later behaviour (Bamberg et al., 2003).

In particular, and interestingly, there is only one participant out of the 46 who agrees that saving time, learning new routes, reducing his environmental impacts and changing his mobility behaviour were facilitated by the Smartmoov' app. This participant stated, as well, that he is ready to pay for using this multimodal application.

Before the experimentation 39 participants expressed their intention of using Smartmoov' to plan daily travels and 45 participants for occasional travels. However, after the experimentation, the results were in line with previous studies: few people used Smartmoov' for daily travels (12 participants) and for planning daily travels (21 participants), while it was most often used to plan occasional travels (28 participants). This result confirms the finding of Bonsall and Joint (1991) that refer that information was largely consulted in unfamiliar travels, whereas for the familiar travels was consulted by only 13%.

In addition, after the experimentation it is possible to observe that the app was mostly used for re-route and pre-trip information. In fact, in case of disturbances on the road, 20 participants stated that they have consulted Smartmoov' and 15 participants consulted Smartmoov' before departing. Finally, only 10 participants declared that they consulted Smartmoov' during the travel (en-route information).

Willingness to pay

The data analysis allows to state that the willingness to pay for using Smartmoov' has decreased after the experimentation: only two people were willing to pay for its use.

While the total number of participants who are willing to pay decreased, the overall amount associate with the grow of time saved increased. This could mean a higher perceived value given to this app if it could effectively help participants to save time.

Ergonomics

The experimentation showed that Smartmoov' app was not easy-to-use. This statement is grounded on the fact that only 15% of the participants' did not faced problems during the daily travels and 30% agreed that Smartmoov' app was a user-friendly app. Another fact is that 46% of the participants agreed that did not lose a lot of time using Smartmoov'.

ATIS have to be intuitive for users, providing low threshold of accessibility and uncomplicated access in order to contribute to an efficient mobility (Gotzenbrucker and Kohl, 2011). Probably, the lack of user friendliness of Smartmoov' can be one of the reasons of the observed unchanged mobility.

Constructs towards modal change

The Theory of planned behaviour showed that subjective norms' constructs do not play a role in the intention to change transport habits. This means that friends, family and policy makers are not a pressure for modal change. In fact, Armitage and Conner (2001) had already concluded that subjective norms were the weakest TPB construct to predict intention. Perceived behavioural control also was not a good predictor. Lee et al. (2010) referred that attitudes towards behaviour had more influence than subjective norms and perceived behaviour control. Indeed, attitudes were the only construct influencing the intention to change transport habits. Attitudes increases the frequency of the intention to maintain the transport habits; the participants who showed a higher attitude scores were less available to change mode. This conclusion is incongruent with the theory: it would be expect that a higher scores in attitudes would produce a higher will to change behaviour.

When crossing these constructs with the mode used was evident that people who use sustainable modes have higher perceived behaviour control and higher attitudes modal shift when comparing with pollutant commuters.

Therefore, if the goal is to achieve a real change of transport habits, throughout the provision of multimodal information systems, the efforts should be focused primarily on behavioural beliefs of the commuters, notably of the pollutant users.

After the experimentation, it was not possible to explain the intention of modal shift using the constructs of Theory of Planned behaviour. It was understood, as well, that for our sample, the intention was not capable to predict the observed modal shift.

Changes were expected on how the participants scored the TPB constructs, but only the subjective norms' (SN) constructs showed significant differences after the experimentation. Therefore, it seems that perceived social pressure (SN) is not a driver for modal shift caused by the use of multimodal real-time information. Behavioural beliefs (ATT) and control beliefs (PBC) did not change significantly with the experimentation. In fact, we expect that the PBC and ATT would increase with the information provided by the app. Our perspective was that real-time information would result in a higher perceived control (PCB) of the mobility; this was not the case.

The stability of the observed behaviour over time could be attributed to the stability of intentions and of perceived behaviour control (Bamberg et al., 2003). These factors presumably determined the behaviour in the past and, as they remained unchanged, produced the corresponding behaviour in the future.

Findings

Information is the backbone of today’s society and there is no doubt that information systems applied to transport networks can be an element towards an urban sustainable mobility. Literature shows that ATIS have a potential to influence mobility behaviour if a variety of preconditions are met. Factors concerning (1) the system, (2) the potential users and (3) the complementary restrictions/investments have to be taken into account when implementing this ATIS.

(1) To influence the mobility behaviour these ATIS systems have to meet all the commuters demands in terms of information and design. Commuters require a free of charge system that is user-friendly with accurate real-time information that reduces journeys uncertainty. In addition, the system should provide a visualization of point-to-point itineraries for multimodal trips to stimulate the combination of different modes, delivering the information when it is needed. Finally, it should give tailored information to increase users’ conviction, but securing privacy and data security. We observed that Smartmoov’ did not meet the pre-requirement of being user-friendly, what could explain the results.

(2) ATIS systems have to be widely known and used by all population groups. These systems maybe will not produce significant changes in all commuters, but they can be efficiently used by small groups. Therefore, as many people have access to them, bigger is the potentiality of increasing the number of this “small groups”. Bigger is this group better is the urban mobility and lower is the relative cost of the ATIS. Our research focused on only 50 participants, and only they had access to the app.

(3) As verified in this research the provision of information, by itself and alone, had little or no impact on the efficiency of the urban transport network, being used only to plan occasional trips or in case of major disruptions. Therefore, much work has to be done in parallel with the development of these systems for the promotion of sustainable commuting. For instance, three major areas should be addressed at the same level as the provision of information:

- improve sustainable transport infrastructures: better network design, increase of frequency of PT, more bike sharing facilities, better bicycle paths;
- anti-Car policies: make towns less attractive for the cars users with more expensive parking, entering town tolls and expensive fuel within the urban area;

- education: educate the citizens about the importance of a sustainable mobility, especially youngsters that have not already created mobility habits, and promote activities that can take the best from commuting time.

Sustainable urban mobility is a complex equation and multimodal information systems are one of the variables to better get it.

Conclusions

The European White Paper (2011) on transport highlights the essential role of ITS in improving the efficiency and reducing the environmental impact of the European transport network in the medium-long term, through the use of better traffic information and management systems, with a view to a multimodal approach for both passenger and freight transport. Within this vision, member states and cities adopted measures to promote the use of high-tech systems for the management of passenger mobility by making available integrated multimodal passenger mobility services that incorporate and include all ITS systems. These multimodal systems focus on people and not on vehicles, through the expansion and integration of individual and collective transport modes with the use of alternative environmentally sustainable vehicles.

Today, many cities have deployed multimodal real-time information systems, but few have assessed the impacts of those systems on traveller behaviour. In effect, the outcome of these systems on mobility are highly dependent on how they are perceived and used by commuters (Götzenbrucker and Köhl, 2011).

This vision guided the investigation, being assessed the introduction of the Smartmoov' application, a mobile multimodal real-time information system implemented in the metropolitan area of Lyon, within the project Optimod'Lyon. The research was divided into two studies: in the first study, using the data collected before the Smartmoov' experimentation, the potential limitations and characteristics that could influence the use of this system were identified; the second study, that crossed the data before and after Smartmoov' experimentation, analysed the changes produced by the use of Smartmoov'.

The aim of the research was to understand if there were constrains to the use of multimodal real-time information. The introduction of this app can be considered by a positive outlook:

- the technological ability was not an obstacle for the use of these technologies because the majority of the participants were capable to use computers, navigator systems and smartphones;
- the participants, when choosing the mode of transport, seek quickness and flexibility/independence, notably the features of Smartmoov';
- the majority of the participants were curious about this system;
- the majority of the participants expected to save time in commuting thanks to Smartmoov';
- the participants agreed that real-time information about passes and schedules of PT would have a positive influence in their ridership.

Besides this positive outlook, the expected impacts of the app on the mobility were relatively low:

- only six out of 26 pollutant commuters intend to change transport mode;
- the participants perceived that this app could be more helpful for not systematic trips;
- only six participants were willing to pay for using Smartmoov';
- the participants were undecided if Smartmoov' app could be an element favouring the modal shift.

We acknowledged that the capacity of Smartmoov' to help commuters to save travel time is critical to its success: more travel time this system is able to reduce bigger is the availability of the participants to pay for its use.

We identified a consensus about the environmental problems: the participants perceived that air and noise pollution and traffic jams are a problem in the area of Lyon. Furthermore, 37 participants agreed that one way to mitigate these problems could be through a more sustainable mobility. However, this environmental conscience was not translated in intention to change mobility patterns, where only 6 out the 26 pollutant commuters were available to change mode. Therefore, we can conclude that sustainable mobility is a typical environment value-action gap, meaning that there is a high awareness and knowledge of the problem, but a relatively low level of intention to act or action (Kollmuss and Agyman, 2002).

In synthesis, in the study 1, it was not recorded any strong constraint on the use of Smartmoov'. Nevertheless, the impact of this app on mobility behaviour seemed very limited.

In the study 2, with the goal to assess the impacts that Smartmoov' had on the mobility of the participants, the data before and after experimentation period were compared. In this study it is possible to recognize that this app alone had no influence on modal shift. Expectations about Smartmoov' were more positive than the reality, as its use shows.

The participants were undecided if this app would be a facilitator or an incentive for the modal shift. After the experimentation there were no doubts: participants disagreed that this app is capable to induce modal diversion.

The real time feature of Smartmoov' did not match the expectations of the participants; 42 people wanted to save time and only 14 really did it. As learnt, in the study 1, the economic success of this app was connected to the time that this app was able to save. Consequently, it was not surprising that the willingness to pay for the use has also decreased after the experimentation. In fact, in mean values, the participants totally disagree that they are willing to pay for using Smartmoov'.

In the city of Stockholm, the introduction of a co-modal application helped the participants to achieve a more sustainable mobility through a greater use of public transport and a reduction of car use (Skoglund and Karlsson, 2012). With the introduction of Smartmoov', in Lyon, we observed the opposite: an increase of the car use for the most frequent travels while the other modes were unchanged after the experimentation. The stability of the mode used shows that past travel choices had strongly contributed to explain later mode used.

The potential of this app to promote a sustainable mobility is quite questionable: the participants stated that this app did not help them to reduce their environmental impact as much as they supposed it could do. In addition, the intention to use more sustainable modes (PT, bike sharing, carpooling) if real-time information is available decreased after the experimentation.

In synthesis, the travellers' assessment of the travel planner was initially modestly positive, but decreased over time.

This negative evaluation of Smartmoov' after the experimentation can be due, partly, to the software himself, where the general overview of the participants was that Smartmoov' app was not easy-to-use, facing problems to use it during the daily commuting. In fact, Fayish and Jovanis (2004) had already observed that, to induce the use of ATIS, travellers ask that the systems are user-friendly, with accurate information and a good graphical design. This evaluation showed that Smartmoov' did not meet yet all the technical preconditions demanded by commuters for having an effect on mobility behaviour.

However, after the experimentation, the results were in line with previous studies, meaning that few people used this app on a daily basis or for planning daily commuting, as it was most often used to plan occasional travels (Bonsall and Joint, 1991; Grotenhuis et al., 2007).

The expert group on Urban ITS conclude that the implementation of the Multimodal information system was the most economical method to get a reduction of 24 000 tons of CO_2/year in Lyon, equivalent to 1% of modal diversion from cars to bikes and/or public transport (Expert Group on ITS for Urban areas, 2011). The results of this research call into question the capacity of these systems alone to get 1% of modal shift. In our opinion, these systems have to be part of a bigger strategy to achieve an urban sustainable mobility, which includes more investment on public transport, on pedestrian/bicycle paths and measures to make difficult the car use.

It was possible to identify that, in this case, the model proposed by the Theory of Planned Behaviour (TPB) was not able to explain the observed traveller behaviour. Before the experimentation, intentions to change mode slightly derived from the personal evaluation of performing the modal shift (attitude towards behaviour, ATT). The other two constructs, subjective norm (SN) and perceived behavioural control (PBC), did not play a role in explaining intentions. After the experimentation, ATT, PBC and intentions did not change significantly. The stability of intentions and of perceived behavioural control could explain the observed behaviour stability. Those factors presumably determined the behaviour in the past and, as it remained unchanged, produced the corresponding behaviour in the future (Bamberg et al., 2003).

The observed lack of fit of the TPB can be the effect of the participants' high frequency of past behaviour, that leads to mobility habits, which strongly influence the process of modal choice. This finding means that the behaviour under consideration, rather than being completely reasoned, is partly under the direct control of the stimulus situation, that is, repeating the habitudinal performance (Bamberg et al., 2003).

Aarts et al. (1997) found that systematic travels limit the effects that information can have on modal diversion because people automatically behave without consulting the available information. Nevertheless routine, the human social behaviour is always regulated at a certain (even if low) level of cognitive effort. Therefore, for achieving a multimodal behaviour, it is essential that the use of information contributes to the disrupt of the routine behaviour and initiates reasoned action (Kenyon and Lyons, 2003).

Mobility habits are a heavy burden on the process of modal choice nevertheless information can play a role, but only if it is strong enough to interrupt the patterns of routine commuters.

The total number of respondents was small ($n_{ex\_ante} = 50$; $n_{ex\_post} = 46$) and, thus, it is not possible to generalize the conclusions. In fact, the majority of the multivariate strategies requires at least 100 persons to achieve good results.

When comparing the results before and after the experimentation, it was impossible to secure a control group since all participants got a Smartphone and used the Smartmoov' app. This limitation is not uncommon in field studies, but it raises the possibility that events other than the introduction of the multimodal app may have produced the observed effects (Bamberg et al., 2003).

Finally, during the experimentation, the Smartmoov' app was updated three times, adding small changes in terms of content and user interface that could cause some bias on the results.

Nevertheless, we stand that this research gives an added value as regards the impacts that multimodal real-time information can have on mobility and can be a starting point for future analysis.

Multimodal traveller information systems are a recent concept and nowadays are spread all over Europe, therefore there is a real need for the assessment of their impacts because many funds are being addressed towards this development, without a real notion of its effectiveness.

The conclusions of this study should be considered with care because the number of participants was not a representation of the population and there was not a control sample with which to compare the results. Therefore, the same research will be carried out with more participants and in different cities within the just started Opticities project (www.opticities.com).

Many ATIS have been implemented all over the world so it would be of major importance the collection and gathering of information about those systems: the business cases; the trend of their use; the features available and more consulted; the types of transport that have already integrated. With this study, it is possible to observe trends and make a proposal that better fits the requirements of the commuters and, ultimately, allows to design more efficient information systems.

In this research it was applied the TPB model as approach to explain the modal diversion in use of real time information. We concluded that, with the available data, this model did not fit the behaviour. Thus, we propose to apply this theory to a larger sample using the findings of this research for the factor constructions. Afterwards, it would be of utmost importance to test other behavioural models to explain the modal shift in case of multimodal real time information. Finally, a mix of models or a new model could be constructed to describe and explain this complex behaviour.

References

Aarts, H., Verplanken, B. and Van Knippenberg, A. (1997). Habit and information use in travel mode choices. *Acta Psychologica, 96*, 1-14.

Abdalla, M. F. and Abdel-Aty, M. (2006). Modeling travel time under ATIS using mixed linear models. *Transportation* (33), 63–82.

Abdel-Aty, M. (2001). Using Ordered Probit Modeling to Study the Effect of ATIS on Transit Ridership. *Transportation Research Part C: Emerging Technologies, 9*, 265-277.

Abdel-Aty, M. (2002). *Design and Development of a Computer Simulation Experiment to Support Mode/Route Choice Modeling in the Presence of ATIS.* Orlando, Florida: Civil and Environmental Engineering Department, University of Central Florida.

Abdel-Aty, M., Kitamura, R., Jovanis, P. and Vaughn, K. (1994). *Investigation of Criteria Influencing Route Choice: Initial Analysis Using Revealed and Stated Preference Data.* Davis: Institute of Transportation Studies, University of California.

Abdel-Aty, M., Kitamura, R. and Jovanis, P. (1995). Understanding the Effect of ATIS on commuters route choice decisions. *Proceedings of the 5th annual Meeting of ITS America*.

Adler, J. and Blue, V. (1998). Toward the design of intelligent travel information systems. *Transportation Research Part C 6*, 157–172.

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes, 50*, 179-211.

Ajzen, I. (2010). *Constructing a theory of planned behavior questionnaire.* Retrieved November 21, 2012, from Icek Ajzen Homepage: http://people.umass.edu/aizen/tpb.html

Ajzen, I. (2012). *TPB Diagram*. Retrieved August 13, 2012, from Icek Ajzen Homepage: http://people.umass.edu/aizen/tpb.diag.html#null-link

Ajzen, I. (2013). *Behavioral Interventions Based on the Theory of Planned Behavior*. Retrieved July 17, 2013, from Icek Ajzen: http://people.umass.edu/aizen/pdf/tpb.intervention.pdf

Ajzen, I. and Cote, N. G. (2008). Attitudes and the Prediction of behavior. In W. D. Crano, and R. Prislin, *Attitudes and attitude change* (pp. 289-311). New York: Psychology Press.

Ajzen, I., Joyce, N., Sheikh, S. and Cote, N. G. (2011). Knowledge and the Prediction of Behavior: The Role of Information Accuracy in the Theory of Planned Behavior. *Basic and applied Social Psycology, 33*, 101–117.

Armitage, C. J. and Conner, M. (2001). Efficacy of the Theory of Planned Behaviour: A meta-analytic review. *British Journal of Social Psychology, 49*, 471–499.

Asakura, Y., Hato, E., Kashiwadani, M. and Katsuki, S. (2000). The Simulation Study of Traffic Information Strtegies Using the Computer for Data Colletion on Drivers' Responses to ATIS. *Fifth International Conference on Urban Transport and the Environment for the 21st Century*, 343-352, Southampton: WIT Press.

Bamberg, S., Ajzen, I. and Schmidt, P. (2003). Choice of Travel Mode in the Theory of Planned Behavior: The Roles of Past Behavior, Habit, and Reasoned Action. *Basic and Applied Social Psychology, 25(3)*, 175–187.

Biernbaum, L., Rainville, L. and Spiro, A. (2011). *Multimodal Trip Planner System Final Evaluation Report.* Chicago: Research and Innovative Technology Administration - U.S. Department of Transportation.

Body, A. (2007). Regional Update: Signal Pre-Emption and Improvements to Real-Time Passenger Information Are Playing a Key Role in Improving Passenger Transport Patronage and reducing Road Congestion in the Auckland Region. *ITS International, 13*, 33-34.

Böhn, M. and Lamprecht, G. (2009). *D1.1.1 In-Time project presentation*. Retrieved August 13, 2012, from In-Time: http://www.in-time-project.eu/en/library/deliverables/

Bonsall, P. and Joint, M. (1991). Driver compliance with route guidance advice: The evidence and its implications. *Vehicle Navigation and Information Systems Conference*, *2*, 47-59. Warrendale, PA, USA.

Brasoveanu, F., Petru, A. and Brezeanu, L. (2010). The Schengen Agreement and the Free Movement within the European Union. *Ovidius University Annals, Economic Sciences Series, X*, 376-378.

Brown, S. (2011). *Measures of Shape: Skewness and Kurtosis.* Retrieved November 04, 2013, from Tompkins Cortland Community College: http://www.tc3.edu/instruct/sbrown/stat/shape.htm

Budaev, S. (2010). Using principal components and factor analysis in animal behaviour research: Caveats and guidelines. *Ethology, 116*, 472-480.

Bunch, J., Burnier, C., Greer, E., Hatcher, G., Jacobi, A., Kabir, F., . . . Wochinger, K. (2011). *Intelligent Transportation Systems Benefits, Costs, Deployment, and Lessons Learned Desk Reference:2011 Update.* Washington: ITS-Joint Program Office RITA.

Burden, R. (2012). *The Source.* Retrieved November 04, 2012, from LAX Radio and the Origin of the Travelers Information Service: http://www.theradiosource.com/downloads/2012-burden-lax-history-of-tis.pdf

Casas Vilaró, J. (1998). *Traffic Demand Estimation in real-time applications.* Barcelona: Universitat Politécnica de Catalunya.

Cestac, J. (2009). *Habitude et principe de compatibilité dans le modèle du comportement planifié: Décisions pro-environnementales et automobile.* Paris: Universite Paris Ouest Manterre la Defense.

Cham, L., Darido, G., Jackson, D., Laver, R., Booz, A. and Schneck, D. (2006). *Real-time Bus Arrival Information Systems Return-on-Investment Study – Final Report. National Technical Information Service.* Washington, DC: Federal Transit Administration.

Chorus, C., Molin, E., Van Wee, B., Arentze, T. and Timmermans, H. (2006). Responses to transit information among car-drivers: regret-based models and simulations. *Transportation Planning and Technology 29*, 249–271.

Chorus, G. G., Molin, E. J. and Van Wee, B. (2006). Use and Effects of Advanced Traveller Information Services (ATIS): A Review of the Literature. *Transport Reviewes, 26, 2*, 127-149.

Chun-Hsin Wu, D.-C. S., Chang, J., Wei, C.-C., Ho, J.-M., Lin, K.-J. and Lee, D. (2003). *An Advanced Traveler Information System with Emerging Network Technologies.* Retrieved May 12, 2012, from http://www.iis.sinica.edu.tw/papers/dtlee/1544-F.pdf

Cortina, J. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of Applied Psychology, 78*, 98-104.

Cross, B. (2003). Texting for bus info: internet and SMS information service are boosting ridership. *ITS International, 9*, 38-39.

d'Ardenne, J., McManus, S. and Hall, J. (2011). *Designing survey questions on food-related issues: Question design toolkit based on a theory of behavioural change.* NatCen - National center for socail research.

Davidson, A. (2009). *RouteRank.* Retrieved Setember 01, 2013, from MPhil in Statistical Science 2008-9: http://www.statslab.cam.ac.uk/Postgrad/Projects/projects09.pdf

de Ven, T. and Wedlock, M. (2011). *ITS ACTION PLAN - Study regarding guaranteed access to traffic and travel data.* Retrieved July 27, 2011, from http://ec.europa.eu/transport/its/studies/doc/2011_03-final-report-study-data-access-free-safety-traffic-information.pdf

Dudek, C. L. (2004). *Changeable Message Sign Operation.* Washington, D.C.: Federal Highway Administration.

European Commission. (2011). *White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system.* Brussels: Europena Commission.

European Commission. (2013). *EU Transport in figures - Statistic Poketbook 2013.* Luxembourg: Publications Office of the European Union.

European Commission. (2014). *Intelligent transport systems*. Retrieved January 16, 2014, from Mobility and Transport: http://ec.europa.eu/transport/themes/its/index_en.htm

Expert Group on ITS for Urban areas. (2011). *Guidelines "Multimodal Information".* Retrieved February 4, 2014, from European Commission - Directorate-General for Mobility and Transport: http://www.predim.org/IMG/pdf/Urban_ITS_Expert_Group_-_DraftGuidelines_-_Multimodal_information_service.pdf

Ezell, S. (2010). *Explaining International IT Application Leadership: Intelligent Transportation Systems.* Retrieved January 16, 2014, from ITIF: http://www.itif.org/publications/explaining-international-it-application-leadership-intelligent-transportation-systems

Fabrigar, R., Wegener, D., MacCallum, R. and Strahan, E. (1999). Evaluating the Use of Exploratory Factor Analysis in Psychological Research. *Psychological Methods, 4*, 272-299.

Fayish, A. C. and Jovanis, P. P. (2004). Usability of Statewide Web-Based Roadway Weather Information System. *Transportation Research Record: Journal of the Transportation Research Board*, 44-54.

Field, A. (2000). *Discovering statistics: Using SPSS for Windows.* London: Sage.

Fife-Schaw, C. (2013). *Statistics FAQ*. Retrieved November 12, 2013, from university of Surrey: http://www.surrey.ac.uk/psychology/current/statistics/index.htm

Fishmana, E., Washingtonab, S. and Hawortha, N. (2013). Bike Share: A Synthesis of the Literature. *Transport Reviews: A Transnational Transdisciplinary Journal, 33*(2), 148-165.

Francis, J., Eccles, M., Johnston, M., Walker, A., Grimshaw, J., Foy, R., . . . Bonetti, D. (2004). *Construting questionnaires based on the theory of planned behavior.* Quality of life and management of living resources, Newcastle.

Gärling, T. and Axhausen, K. (2003). Introduction: Habitual travel choice. *Transportation, 30*, 1-11.

Giannopoulos, G. (2004). The application of information and communication technologies in transport. *European Journal of Operational Research, 152*, 302-320.

Gillen, D. and Johnson, D. (2002). *Bus Rapid Transit and the use of AVL Technology: A Survey of Integrating Change.* Berkeley: California Partners for Advanced Transit and Highways.

Godin, G. and Kok, G. (1996). The theory of planned behavior: A review of its applications to health-related behaviors. *American Journal of Health Promotion, 11*, 87–98.

Google. (2013). *Google Transit*. Retrieved August 23, 2013, from Google Transit Partner Program: http://maps.google.com/help/maps/mapcontent/transit/

Gotzenbrucker, G. and Kohl, M. (2011). Sustainable Future Mobility by ICTs. The impacts of Advance Traveler Information Systems on mobility behavior. *8th ITS European Congress*, 1-15.

Grace-Martin, K. (2008). *Can Likert Scale Data ever be Continuous?* Retrieved January 05, 2014, from The Analysis Factor: http://www.theanalysisfactor.com/can-likert-scale-data-ever-be-continuous/

Grotenhuis, J., Wiegmans, W. and Rietveld, P. (2007). The desired quality of integrated multimodal travel information in public transport: customer needs for time and effort savings. *Transport Policy, 14*, 27–38.

Groves, R., Fowler, F., Couper, M., Lepkowski, J., Singer, E. and Tourangeau, R. (2004). *Survey methodology.* Hoboken, New Jersey: Wiley and Sons.

Harris, P. and Konheim, C. (1995). The Public's Interest In And Willingness To Pay For Enhanced Traveler Information As Provided By Ivhs In The New York Metropolitan Area. *ITS America 1995 Annual Conference.* Washington, DC.

Harvey, S. (1998). *Real Time Traffic Information Systems.* Retrieved August 13, 2013, from Supplement to HandT March 1998: http://www.ciht.org.uk/download.cfm/docid/19FDA420-28AE-40CB-9909C1EB987F9C1F.

Hato, E., Taniguchi, M., Sugie, Y., Kuwahara, M. and Morita, H. (1999). Incorporating an information acquisition process into a route choice model with multiple information sources. *Transportation Research Part C 7*, 109–129.

Holdsworth, N., Enoch, M. and Ison, S. (2007). Examining the political and practical reality of bus-based real time passenger information. *Transportation Planning and Technology 30*, 183–204.

Hope, S. and King, S. (2006). *Contribution Made by TRAVELINE Scotland to Modal Shift.* Scottish Executive Social Research.

Hwang, M., Kemp, J., Lerner-Lam, E., Neuerburg, N. and Okunieff, P. (2006). Chapter 5: Traveler Information. In J. Schiavone, *Advanced Public Transportation Systems: State of the Art Update 2006*, 170-192. Tenafly: U.S. Department of Transportation.

Hyejung, H. (2009). *Measuring the Effectiveness of Advanced Traveler Information Systems (ATIS).* Raleigh, North Carolina: North Carolina State University.

Jou, R. (2001). Modeling the impact of pre-trip information on commuter departure time and route choice. *Transportation Research Part B: Methodological, 35*, 887–902.

Kahn, J. (2006). Factor analysis in counseling psychology research, training, and practice: Principles, advances, and applications. *The Counseling Psychologist, 34*, 684-718.

Kaiser, H. (1974). An index of factorial simplicity. *Psychometrika, 39*, 31-36.

Keller, H. (1999). *Concertation and Achievements Report of the Transport Sector.* Brussels: Telematics Applications Programme.

Kenyon, S. and Lyons, G. (2003). The Value of Integrated Multimodal Traveller Information and its Potential Contribution to Modal Change. *Transportation Research Part F Traffic Psychology and Behaviour, 6 (1)*, 1-21.

Khattak, A. J., Schofer, J. L. and Koppelman, F. S. (1993). Commuters' En-route Diversion and Return Decisions: Analysis and Implications for Advanced Traveler Information Systems. *Transport Research Board, 27A*(2), 101-111.

Khattak, A. J., Yim, Y. and Prokopy, L. S. (2003). Willingness to pay for travel information. *Transportation Research Part C 11*, 137–159.

Kim, K. and Vandebona, U. (2002). Understanding route change behaviour – a commuter survey in South Korea. *Transportation Research Board 81st Annual Meeting.* Washington, DC: TRB.

Kollmuss, A. and Agyman, J. (2002). Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research, 8*, 239-260.

Kumar, P., Reddy, D. and Singh, V. (2003). Intelligent transportation system using GIS. *Proc. Map India Int. Conf. GIS.* Nova Delhi: GPS, Aerial, Photography, and Remote Sensing.

Kuwahara, M. (1998). *Intelligent Transport Systems - Overview and Japanese Systems.* Tokyo: Institute of Industrial Science, University of Tokyo.

Lappin, J. and Bottom, J. (2001). *Understanding and Predicting Traveler Response to Information: Traveler Response to Information: .* Technical Report No.: FHWA-JPO-04-014, US Department of Transportation.

Lee, J., Cerreto, F. A. and Lee, J. (2010). Theory of Planned Behavior and Teachers' Decisions Regarding Use of Educational. *Educational Technology and Society, 13 (1)*, 152–164.

Lehtonen, M. and Kulmala, R. (2002). The benefits of a pilot implementation of public transport signal priorities and real-time passenger information. *Transportation Research Record, 1799*, 18–25.

Lively, D. and Elhamshary, O. (2005). *551 Depoyment Coalition.* Retrieved May 15, 2014, from Lessons Learned From Advanced Traveler Information Systems: Applications for Emergency Management And Long Term Disaster Recovery: www.deploy511.org

London Transport. (1998). *Survey Finds London Transit Info Changes Behavior, Creates Revenue.* London: Inside ITS.

Lyons, G. and Harman, R. (2002). The UK public transport industry and provision of multi-modal traveller information. *International Journal of Transport Management 1*, 1-13.

Lyons, G., Avineri, E. and Farag, S. (2008). Assessing the demand for travel information: Do we really want to know. *Proc. European Transport Conference.*

Maccubbin, R. P., Staples, B. L., Kabir, F., Lowrance, C. F., Mercer, M. R., Philips, B. H. and Gordon, S. R. (2008). *Intelligent Transportation systems Benefits, Costs, Deployment, and Lessons Learned: 2008 Update.* Washington, D.C.: Department of Transportation Research and Innovative Technology Administration Intelligent Transportation Systems Joint Program Office.

Mahmassani, H. (1997). Dynamics of commuter behaviour: Recent research and continuing challenges. In P. Stopher, and M. Lee-Gosselin, *Understanding Travel Behaviour in an Era of Change*, 279–313, Oxford: Pergamon Press.

Mahmassani, H., Huynh, N., Srinivasan, K. and Kraan, M. (2003). Tripmaker choice behavior for shopping trips under real-time information: model formulation and results of stated-preference internet-based interactive experiments. *Journal of Retailing and Consumer Services, 10*(6), 311-321.

Martinez, L. and Ferreira, A. (2008). *Análise de Dados com SPSS - Primeiros Passos.* Lisboa: Escolar Editora.

McDonald, J. (2009). Small numbers in chi-square and G-tests. In *Handbook of Biological Statistics* (Vol. 2, pp. 80-83). Baltimore, Maryland: Sparky House Publishing. Retrieved from Handbook of Biological Statistics.

Molin, E., Chorus, C. and Van Sloten, R. (2009). The Need for Advanced Public Transport Information Services When Making Transfers. *EJTIR*, 397-410.

Morgan, D. and Krueger, R. (1993). When to use focus groups and why:Successful focus groups: advancing the state of the art. *Sage focus editions, vol 156*, 3-19.

Nagaraj, U. (2011). Intelligent Public Transport Information System. *International Journal on Computer Science and Engineering (IJCSE), 3*, 2635 - 2641. Retrieved June 2012, 27, from citeseerx.ist.psu.edu/

Neuherz, M., Patz, V., Pischner, T. and Keller, H. (2000). *User acceptance and impacts of new multimodal traffic information systems in Bayerninfo.* Retrieved August 09, 2013, from http://irandanesh.febpco.com/FileEssay/barnamerizi-1386-12-8-bgh(104).PDF

Optimod'Lyon. (2013). *Optimod'Lyon*. Retrieved February 12, 2013, from Optimiser la mobilitè durable en Ville: http://www.optimodlyon.com/accueil

Oulette, J. and Wood, W. (1998). Habit and intention in everyday life: the multiple processes by which past behavior predicts future behavior. *Psychological Bullettin*.

Peirce, S. and Lappin, J. (2004). Why don't more people use advanced traveler information? Evidence from the Seattle area. *Transportation Research Board 83rd Annual Meeting.* Washington, DC.

Petrella, M. and Lappin, J. (2007). Comparative Analysis of Customer Response to Online Traffic Information in Two Cities. Los Angeles, California, and Seattle, Washington. *Transportation Research Record: Journal of the Transportation Research Board, 1886*, 10-17.

Polak, J. and Jones, P. (1993). The acquisition of pre-trip information: a stated preference approach. *Transportation, 20*, 179-198.

Polydoropoulou, A. and Ben-Akiva, M. (1998). The effect of advanced traveller information systems. In R. H. Emmerink, and P. Nijkamp, *Behavioural and Network Impacts of Driver Information Systems.*

Potoènik, J. (2008). Making the European transport industry "greener, safer and smarter" to boost our industrial competitiveness. *Speech at Transport Research Arena Opening Ceremony*. Ljubjana.

Pronello, C. and Camusso, C. (2011). Travellers' profiles definition using statistical multivariate analysis of attitudinal variables. *Journal of Transport Geography, 19 (6)*, 1294–1308.

Regional Transportation Authority. (2013). *RTA Trip Planner*. Retrieved August 24, 2013, from Goroo: http://goroo.com/goroo/showLearnMore.htm

RITA. (2012). *Research and Innovative Technology Administration.* Retrieved December 20, 2012, from Intermodal Surface Transportation Efficiency Act of 1991: http://ntl.bts.gov/DOCS/istea.html

RITA. (2013). *1.1 Pre-trip Travel Information*. Retrieved January 28, 2013, from The National ITS Architecture 7.0: http://www.iteris.com/itsarch/html/user/usr11.htm

RITA. (2013). *1.2 En-route Driver Information*. Retrieved January 28, 2013, from The National ITS Architecture 7.0: http://www.iteris.com/itsarch/html/user/usr12.htm

RITA. (2013). *Benefits Database Overview*. Retrieved January 28, 2013, from Intelligent Transportation Systems Joint Program Office: http://www.itsbenefits.its.dot.gov/

Rodriguez, G. (2007). *Logit Models for Binary Data (Chapter 3).* Retrieved January 28, 2013, from Princeton University: http://data.princeton.edu/wws509/notes/c3.pdf

Rolefson, K. (2003). Real-time passenger information, real-time benefits. *2003 Bus and Paratransit Conference Proceedings.* American Public Transportation Association.

Russo, D. A., Stochl, J., Croudace, T. J., Graffy, J. P., Youens, J., Jones, P. B. and Perez, J. (2011). Use of the theory of planned behaviour to assess factors influencing the identification of individuals at ultra-high risk for psychosis in primary care. *Early Intervention in Psychiatry 2011*.

SAS. (2013). *Usage Note 23136: What does it mean if the intercept is/is not significant? Should I remove it from my model?* Retrieved December 12, 2013, from SAS support: http://support.sas.com/kb/23/136.html

Schwartz, N., Hippler, H., Deutsch, B. and Strack, F. (1985). Questions and answers in attitude surveys:Experiments in question form, wording, and context. *Public Opinion Quarterly, 49*, 388-395.

Schweiger, C. (2003). *Real-time Bus Arrival Information Systems.* Retrieved August 08, 2012, from TCRP Synthesis of Transit Practice No. 48 - Transportation Research Board: http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_syn_48.pdf

Shaheen, S., Guzman, S. and Zhang, H. (2010). Bikesharing in Europe, the Americas, and Asia. *Journal of the Transportation Research Board, 2143*, 159–167.

Sheeran, P. (2002). Intention–Behavior Relations: A Conceptual and Empirical Review. In W. Stroebe, and M. Hewstone. John Wiley and Sons, Ltd.

Shekhar, S. and Liu, D. (1994). *Genesis and Advanced Traveler Information Systems: Killer Applications for Mobile Computing?* Minneapolis: Department of Computer Science.

Simonelli, G. N. and Bifulco, F. (2005). The effects of ATIS on transportation systems: theoretical analysis and numerical applications. *77*, 723-732. WIT Transactions on The Built Environment.

Skår, S. and Sniehotta, F. F. (2008). Prediction of Behaviour vs. Prediction of Behaviour Change: The Role of Motivational Moderators in the Theory of Planned Behaviour. *APPLIED PSYCHOLOGY: AN INTERNATIONAL REVIEW, 57, 4*, 609–627.

Skoglund, T. and Karlsson, M. (2012). Appreciated – but with a fading grace of novelty! Traveller's assessment of, usage of and behavioural change given access to a co-modal travel planner. *Procedia - Social and Behavioral Sciences, 48*, 932 – 940.

Smart-Way. (2012). *Smart-Way final report.* Smart-Way project.

T3 Design. (2010). *Automated Parking Information System Operational Test Evaluation.* Washington, DC: Federal Transit Administration, Office of Research, Demonstration, and Innovation, U.S. Department of Transportation.

Takeuchi, K. and Maeda, S. (2007). Outlook of the next steps of intelligent transpots systems (IST) technologies in Japan: for overcoming Social and Environmental problems brought by Automobiles. *Science and Technology Trends, 22*, 25-44.

Tang, L. and Thakuriah, P. (2012). Ridership effects of real-time bus information system: A case study in the City of Chicago. *Transportation Research Part C*, 146–161.

Transportation Research Board. (2011). *Use and Deployment of Mobile Device Technology for Real-Time Transit Information.* Washington, DC: Transit Cooperative Research Program.

UK Department for transport. (2007). *Towards a Sustainable Transport System - Supporting Economic Growth in a Low Carbon World.* London: Department for transport.

Vance, C. and Balcombe, R. (1997). How to tell bus passengers what they need to know. *Public Transport Planning and Operations,* 231-242, Brunel University, United Kingdom: PTRC Education and Research Services Limited.

Vaugh, K., Reddy, P., Abdel-Aty, M., Kitamura, R. and Jovanis, P. (1995). Route Choice and Information Use: Initial Results Simulation Experiment. *Transportation Research board, 74th Annual meeting.* Washington, D.C.

Wholey, J., Hartry, H. and Newcomer, K. (2004). *Handbook of practical program evaluation.* San Francisco, CA: Wiley and Sons.

Williams, B. M., Hu, H., Khattak, A. J., Rouphail, N. M. and Xiaohongand, P. (2008). *Effectiveness of Traveler Information Tools.* Raleigh: North Carolina State University.

Wolinetz, L., Khattak, A. J. and Yim, Y. (2001). TravInfo Evaluation:Traveler Response Element Willingness to Pay for Traveler Information:Analysus of Wave 2 Broad Area Survey. *California Partners for Advanced Transit and Highways (PATH) UC Berkeley*.

Wolinetz, L., Khattak, A. J. and Yim, Y. B. (2004). Why will some individual pay for travel information when it can be free? Analysis of a Bay Area Traveller Survey. *80th annual Meeting of the Transportation Research Board* (pp. 9-18). Washington, DC, USA: Transportation Research Board.

World Bank. (2013). *Data*. Retrieved August 13, 2012, from World Bank Website: http://data.worldbank.org/

World Road Association. (2002). *Road Network Operations Handboook 2002.* World Road Association.

Zhang, F., Shen, Q. and Clifton, K. (2008). Examination of traveler responses to real-time information about bus arrivals using panel data. *Transportation Research Record 2082*, 107–115.

Zhang, L. and Levinson, D. (2008). Determinants of Route Choice and Value of traveler Information. *Transportation Research Record: Journal of the Transportation Research Board*, 81-92.

Appendices

Appendix I – Normality study for variables used on the Study 1

Ought to remember that the criteria used on this thesis to assume the normality of the variables was that Skewness and Kurtosis values had to be between -1.5 and +1.5 and present a z-score lower than 1.96.

Table 61 – Reasons Skewness and Kurtosis values

	Variables	Mode	N	Skewness	Z-scores	Kurtosis	Z-scores
Reasons	Security Accidents	Pollutant	26	.16	.34	-1.17	-1.21
		Sustainable	24	-.25	-.49	-1.26	-1.26
	Security Agressions	Pollutant	26	-.05	-.11	-1.62	-1.68
		Sustainable	24	.73	1.46	-.99	-.99
	Cost	Pollutant	26	-.02	-.04	-1.20	-1.24
		Sustainable	24	-.90	-1.79	-.24	-.24
	Quickness	Pollutant	26	-1.34	-2.79	.67	.70
		Sustainable	24	-1.39	-2.79	1.61	1.61
	More Comfort	Pollutant	26	-1.07	-2.22	.32	.34
		Sustainable	24	-.24	-.47	-.88	-.88
	Pleasure	Pollutant	26	-.18	-.37	-1.12	-1.17
		Sustainable	24	-.46	-.92	-1.00	-1.00
	Flexibility and independence	Pollutant	26	-1.31	-2.72	.47	.49
		Sustainable	24	-.72	-1.45	-.95	-.95
	Respect for Environment	Pollutant	26	.19	.39	-1.03	-1.08
		Sustainable	24	-.63	-1.27	-1.12	-1.12
	No other mode available	Pollutant	26	.00	.00	-1.77	-1.85
		Sustainable	24	.84	1.67	-.85	-.85
	Possibility of transporting people or objects	Pollutant	26	-1.11	-2.32	-.23	-.24
		Sustainable	24	.31	0.62	-1.71	-1.71
	Have to use car	Pollutant	26	-1.07	-2.22	.32	.34
		Sustainable	24	1.14	2.28	-.21	-.21

Table 62 – Personal Mobility Attitudes Skewness and Kurtosis values

	Variables	Mode	N	Skewness	Z-scores	Kurtosis	Z-scores
Personal Mobility Attitudes	My usual travel takes too long	Pollutant	26	-.66	-1.370	-.36	-.371
		Sustainable	24	.25	.505	-1.41	-1.407
	For me. travel time is waste of time	Pollutant	26	-.72	-1.491	-.69	-.715
		Sustainable	24	.33	.661	-.79	-.794
	I spend too much money for my regular travel	Pollutant	26	-.21	-.432	-1.50	-1.558
		Sustainable	24	.58	1.153	-1.11	-1.109
	I like to travel by car	Pollutant	26	-.38	-.795	-1.27	-1.324
		Sustainable	24	-.12	-.233	-1.37	-1.369
	I prefer to move fast as possible. even if it causes me a little stress	Pollutant	26	-.68	-1.407	-.67	-.694
		Sustainable	24	.39	.785	-1.27	-1.266
	I feel wasting time when I take the bike or Vélo'v	Pollutant	26	.72	1.495	-.97	-1.010
		Sustainable	24	1.05	2.106	-.58	-.582
	I feel wasting time when I take the TCL or TER (excluding waiting time)	Pollutant	26	.16	.331	-1.32	-1.371
		Sustainable	24	.66	1.324	-1.20	-1.203
	I feel wasting time when I travel by car	Pollutant	26	.34	.707	-.58	-.602
		Sustainable	24	.48	.960	-1.16	-1.156
	I prefer to move peacefully. even if it takes me a little longer	Pollutant	26	.31	.645	-1.10	-1.144
		Sustainable	24	-.69	-1.374	-0.73	-.731
	I love drive on my most frequent trip	Pollutant	26	-.61	-1.280	-.42	-.434
		Sustainable	24	1.60	3.195	1.92	1.919
	I like to carpool on my most frequent trip	Pollutant	26	.19	.404	-1.04	-1.081
		Sustainable	24	.89	1.787	-.70	-.700
	I like to do my most frequent travel with Public Transport	Pollutant	26	.67	1.386	-.73	-.755
		Sustainable	24	-.22	-.443	-1.39	-1.386
	I like to walk on foot to my most frequent travel	Pollutant	26	.87	1.817	-.30	-.309
		Sustainable	24	.14	.286	-1.31	-1.312

Table 63 – Real-time Skewness and Kurtosis values

	Variables	Mode	N	Skewness	Z-scores	Kurtosis	Z-scores
Real -time	I would use the PT more often if I had real-time information on schedules and passes	Pollutant	26	.07	.151	-1.35	-1.409
		Sustainable	24	-.93	-1.856	-.35	-.353
	I would use my car more often if I had real-time traffic information	Pollutant	26	-.42	-.867	-1.14	-1.188
		Sustainable	24	1.25	2.504	.62	.623

Table 64 – Technological Familiarity Skewness and Kurtosis values

	Variables	Mode	N	Skewness	Z-scores	Kurtosis	Z-scores
Techn Familiarity	Desktop/Portable competences	Pollutant	26	-1.31	-2.72	.47	.49
		Sustainable	24	-.88	-1.75	.58	.58
	Ebook competences	Pollutant	26	.64	1.33	-.98	-1.01
		Sustainable	24	.69	1.39	-1.05	-1.05
	Smartphone competences	Pollutant	26	-.91	-1.88	.10	.10
		Sustainable	24	-.60	-1.21	-.81	-.81
	GPS Navigator competences	Pollutant	26	-1.08	-2.24	.33	.34
		Sustainable	24	-.84	-1.68	1.04	1.04

Table 65 – Technological interest Skewness and Kurtosis values

	Variables	Mode	N	Skewness	Z-scores	Kurtosis	Z-scores
Techn interest	I have a good familiarity with iOS	Pollutant	26	-.41	-.845	-1.54	-1.604
		Sustainable	24	.93	1.863	-.67	-.669
	I need lots of technological tools in my daily life	Pollutant	26	-.53	-1.111	-.74	-.771
		Sustainable	24	-.11	-.229	-1.55	-1.550

Table 66 – Smartmoov' Skewness and Kurtosis values

Variables	Mode	N	Skewness	Z-scores	Kurtosis	Z-scores
I expect that public policy makers put pressure on me to limit the environmental impact of my displacement	Pollutant	26	-.14	-.290	-1.19	-1.234
	Sustainable	24	.44	.884	-1.19	-1.193

Appendix II – Factor Analysis BMDP Output

```
BMDP4M - FACTOR ANALYSIS

Copyright 1977, 1979, 1981, 1982, 1983, 1985, 1987, 1988, 1990, 1993
                 by BMDP Statistical Software, Inc.

  Statistical Solutions Ltd.         | Statistical Solutions
  Unit 1A, South Ring Business Park | Stonehill Corporate Center, Suite 104
  Kinsale Road, Cork, Ireland       | 999 Broadway, Saugus, MA 01906, USA
  Phone: + 353 21 4319629           | Phone: 781.231.7680
  Fax:   + 353 21 4319630           | Fax:   781.231.7684
  e-mail:  sales@statsol.ie         | e-mail: info@statsolusa.com
  Website: http://www.statsol.ie    | Website: http://www.statsolusa.com

Release: 8.1  (Windows 9x, 2000, Me, Xp)         Date: 03/18/14  at 11:36:43
 Manual: BMDP Manual Volumes 1, 2, and 3.
 Digest: BMDP User's Digest.
 IBM PC: BMDP PC Supplement -- Installation and Special Features.

PROGRAM INSTRUCTIONS

  / Input
      File = 'C:\Users\Alvaro\Desktop\Logit.txt'.
      Variable = 87.
      Format is free.
      Mchr = '*'.
      RECLEN=800.

 / VARIABLE NAMES = sec_acc,sec_agr,cout,rapidite,comfort,plaisir,
 flex_ind,environ,pasautre,pers_obj,voi_dpf,ai_per_v,dhab_trt,ai_navet,
 prof_tna,dpf_vag,td_tper,dhab_trov,ai_dep_v,mi_rapAB,mi_ecoAB,cour_ar,
 pr_vi_st,pr_au_co,i_ch_hat,pt_vel,pt_map,pt_att,pt_tcter,pt_voi,pr_pa_pt,
 ai_voi_d,ai_cov_d,ai_tcl_d,ai_map_d,ai_vel_d,pie_aq,pa_pal,ps_pal,ar_pal,
 em_pal,em_apa,md_aqval,ps_tc_tr,ps_ve_pc,ps_vv_tr,ps_al_om,ps_al_tr,
 ps_al_it,ps_co_tr,ps_vo_it,ai_trat,pa_prot,i_tech,pae_sgps,app_quot,
 app_amus,amus_ra,fam_and,fam_ios,bbot_quo,ot_inut,meme_tel,mmoi_gps,
 ot_cerv,app_aid,agr_sm,vgt_sm,igt_sm,alie_sm,vlie_sm,ilie_sm,cur_sm,
 pdp_sm,ipdq_sm,a_appfac,v_appfac,ipdo_sm,payer_sm,iccm_sm,usm_fccm,
 adpi_sm,afai_sm,adpp_lie,afap_lie,SustAH,SustPE.
```

```
 USE = afap_lie,afai_sm,adpi_sm,adpp_lie,ai_voi_d,ai_dep_v,ps_vv_tr,
 ps_tc_tr.


 / FACTOR METHOD = PCA.
      CONSTANT = 1.

  / ROTATE METHOD = DQUART.

  / PRINT LOLEV = 0.30.
      FSCF.
      STANDARD.
      INVERSE.
      PARTIAL.

  /end

PROBLEM TITLE IS
03/18/14                11:36:43

NUMBER OF VARIABLES TO READ . . . . . . . . . . .      87
NUMBER OF VARIABLES ADDED BY TRANSFORMATIONS. .         0
TOTAL NUMBER OF VARIABLES . . . . . . . . . . .      87
CASE WEIGHT VARIABLE. . . . . . . . . . . . . .
CASE LABELING VARIABLES . . . . . . . . . . . .
NUMBER OF CASES TO READ . . . . . . . . . . . . TO END
MISSING VALUES CHECKED BEFORE OR AFTER TRANS. . NEITHER
BLANKS IN THE DATA ARE TREATED AS   . . . . . . MISSING
INPUT FILE. . .C:\Users\Alvaro\Desktop\Logit.txt
REWIND INPUT UNIT PRIOR TO READING. . DATA. . .     YES
NUMBER OF INTEGER WORDS OF MEMORY FOR STORAGE .  102400

VARIABLES TO BE USED
    85 afap_lie   83 afai_sm    82 adpi_sm    84 adpp_lie   32 ai_voi_d
    19 ai_dep_v   46 ps_vv_tr   44 ps_tc_tr

DATA FORMAT:  FREE

THE LONGEST RECORD MAY HAVE UP TO  800 CHARACTERS.

 CASE   85       83       82       84       32       19       46       44
  NO. afap_lie afai_sm  adpi_sm  adpp_lie ai_voi_d ai_dep_v ps_vv_tr ps_tc_tr
----- -------- -------- -------- -------- -------- -------- -------- --------
    1     1.00     1.00     5.00     5.00     4.00     4.00     1.00     5.00
```

2	1.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00
3	1.00	3.00	5.00	1.00	3.00	3.00	2.00	4.00
4	1.00	1.00	1.00	1.00	1.00	4.00	1.00	2.00
5	2.00	3.00	3.00	2.00	1.00	3.00	1.00	5.00
6	1.00	1.00	1.00	2.00	5.00	5.00	3.00	2.00
7	2.00	2.00	4.00	4.00	4.00	4.00	2.00	2.00
8	1.00	1.00	4.00	2.00	3.00	4.00	5.00	3.00
9	1.00	1.00	1.00	4.00	1.00	2.00	1.00	2.00
10	4.00	4.00	4.00	4.00	3.00	3.00	2.00	2.00

NUMBER OF CASES READ.   50

DESCRIPTIVE STATISTICS OF DATA
----------- ---------- -- ----

VARIABLE NO.	NAME	TOTAL FREQ.	MEAN	STANDARD DEV.	ST.ERR OF MEAN	COEFF OF VAR	SMALLEST VALUE	SMALLEST Z-SCR	SMALLEST CASE	LARGEST VALUE	LARGEST Z-SCR	LARGEST CASE	RANGE
85	afap_lie	50	2.2000	1.0880	.15386	.49453	1.0000	-1.10	1	5.0000	2.57	13	4.0000
83	afai_sm	50	2.6200	1.1409	.16135	.43545	1.0000	-1.42	1	5.0000	2.09	13	4.0000
82	adpi_sm	50	3.3800	1.1586	.16386	.34279	1.0000	-2.05	4	5.0000	1.40	1	4.0000
84	adpp_lie	50	2.9000	1.3740	.19431	.47378	1.0000	-1.38	2	5.0000	1.53	1	4.0000
32	ai_voi_d	50	2.7400	1.5624	.22096	.57023	1.0000	-1.11	2	5.0000	1.45	6	4.0000
19	ai_dep_v	50	3.4800	1.2974	.18348	.37282	1.0000	-1.91	2	5.0000	1.17	6	4.0000
46	ps_vv_tr	50	2.5800	1.5131	.21398	.58646	1.0000	-1.04	1	5.0000	1.60	8	4.0000
44	ps_tc_tr	50	3.4800	1.3738	.19429	.39477	1.0000	-1.81	2	5.0000	1.11	1	4.0000

CORRELATION MATRIX
----------- ------

		afap_lie 85	afai_sm 83	adpi_sm 82	adpp_lie 84	ai_voi_d 32	ai_dep_v 19	ps_vv_tr 46	ps_tc_tr 44
afap_lie	85	1.0000							
afai_sm	83	0.7366	1.0000						
adpi_sm	82	0.5213	0.5129	1.0000					
adpp_lie	84	0.6007	0.3007	0.4346	1.0000				
ai_voi_d	32	0.1153	0.0808	0.3375	0.0732	1.0000			
ai_dep_v	19	-0.1706	-0.1776	0.0391	-0.1099	0.5964	1.0000		
ps_vv_tr	46	0.2380	0.3313	0.0813	-0.0108	-0.0385	-0.1863	1.0000	
ps_tc_tr	44	0.0164	0.1708	-0.0015	-0.0822	-0.1403	-0.0518	0.3640	1.0000

```
NUMBER OF VARIABLES TO BE USED. . . . . . . . . .    8
UNROTATED FACTORS ARE PRINCIPAL COMPONENTS.
NUMBER OF FACTORS IS LIMITED TO THE NUMBER OF EIGENVALUES
     GREATER THAN     0.900
TOLERANCE LIMIT FOR MATRIX INVERSION. . . . . .   0.00010
DIRECT QUARTIMIN ROTATION FOR SIMPLE LOADINGS IS PERFORMED.
GAMMA . . . . . . . . . . . . . . . . . . . . .    0.0000
MAXIMUM NUMBER OF ITERATIONS FOR ROTATION . . .      50
CONVERGENCE CRITERION FOR ROTATION. . . . . . . 0.0000100
KAISERS NORMALIZATION . . . . . . . . . . . . .     YES
```

STANDARD SCORES VARIABLE INDICES

LABEL	NO.	WEIGHT	85	83	82	84	32	19	46	44
	1	1.000	-1.1	-1.4	1.4	1.5	0.8	0.4	-1.0	1.1
	2	1.000	-1.1	-1.4	-0.3	-1.4	-1.1	-1.9	-1.0	-1.8
	3	1.000	-1.1	0.3	1.4	-1.4	0.2	-0.4	-0.4	0.4
	4	1.000	-1.1	-1.4	-2.1	-1.4	-1.1	0.4	-1.0	-1.1
	5	1.000	-0.2	0.3	-0.3	-0.7	-1.1	-0.4	-1.0	1.1
	6	1.000	-1.1	-1.4	-2.1	-0.7	1.4	1.2	0.3	-1.1
	7	1.000	-0.2	-0.5	0.5	0.8	0.8	0.4	-0.4	-1.1
	8	1.000	-1.1	-1.4	0.5	-0.7	0.2	0.4	1.6	-0.3
	9	1.000	-1.1	-1.4	-2.1	0.8	-1.1	-1.1	-1.0	-1.1
	10	1.000	1.7	1.2	0.5	0.8	0.2	-0.4	-0.4	-1.1
	11	1.000	1.7	1.2	0.5	0.8	1.4	1.2	0.3	-0.3
	12	1.000	-0.2	1.2	0.5	0.1	-1.1	0.4	1.6	1.1
	13	1.000	2.6	2.1	1.4	1.5	0.2	-0.4	0.9	-0.3
	14	1.000	0.7	0.3	0.5	1.5	0.2	-0.4	-1.0	-1.8
	15	1.000	-0.2	-0.5	0.5	-0.7	1.4	1.2	-1.0	0.4
	16	1.000	-0.2	-1.4	0.5	1.5	0.2	0.4	-1.0	-1.1
	17	1.000	-0.2	1.2	0.5	-0.7	1.4	0.4	-0.4	-0.3
	18	1.000	0.7	0.3	-0.3	-1.4	0.2	1.2	0.3	1.1
	19	1.000	0.7	1.2	0.5	0.8	-1.1	-1.9	-1.0	1.1
	20	1.000	-0.2	-0.5	-0.3	0.8	0.2	0.4	-1.0	-0.3
	21	1.000	-1.1	0.3	-0.3	-0.7	1.4	1.2	-0.4	1.1
	22	1.000	0.7	0.3	-0.3	1.5	-1.1	-1.9	1.6	1.1
	23	1.000	0.7	1.2	1.4	0.1	1.4	-0.4	0.9	1.1
	24	1.000	1.7	1.2	1.4	1.5	-0.5	-1.9	1.6	0.4
	25	1.000	0.7	0.3	0.5	0.1	-0.5	-0.4	-0.4	1.1
	26	1.000	0.7	0.3	-0.3	0.1	-1.1	-0.4	-0.4	0.4
	27	1.000	0.7	0.3	-0.3	0.1	1.4	1.2	1.6	1.1
	28	1.000	-0.2	-0.5	-0.3	-0.7	-1.1	0.4	-1.0	1.1
	29	1.000	0.7	0.3	-0.3	0.1	0.2	0.4	-0.4	-0.3
	30	1.000	-1.1	-0.5	-2.1	-1.4	-1.1	-1.1	-1.0	1.1

31	1.000	0.7	1.2	0.5	0.8	1.4	0.4	0.3	0.4
32	1.000	-0.2	-0.5	-1.2	0.1	-1.1	-1.9	1.6	1.1
33	1.000	-1.1	0.3	0.5	-1.4	1.4	1.2	0.9	0.4
34	1.000	-0.2	-0.5	-0.3	-0.7	0.2	-0.4	0.3	1.1
35	1.000	-1.1	-1.4	-2.1	-1.4	-1.1	-0.4	0.9	0.4
36	1.000	0.7	0.3	-0.3	1.5	0.2	0.4	-0.4	1.1
37	1.000	-1.1	1.2	-1.2	-1.4	-1.1	-1.9	1.6	-0.3
38	1.000	-1.1	-1.4	-0.3	-0.7	0.8	0.4	0.3	0.4
39	1.000	-0.2	0.3	-0.3	-0.7	-1.1	0.4	1.6	0.4
40	1.000	0.7	0.3	-0.3	0.1	1.4	1.2	-1.0	-1.8
41	1.000	0.7	0.3	0.5	0.1	1.4	1.2	0.9	-0.3
42	1.000	-0.2	-0.5	1.4	0.8	0.8	1.2	-1.0	-1.1
43	1.000	-0.2	-0.5	0.5	0.1	0.2	0.4	-0.4	-1.1
44	1.000	-0.2	-0.5	0.5	-1.4	-0.5	-0.4	0.9	0.4
45	1.000	-1.1	-1.4	-1.2	0.8	-1.1	1.2	0.3	1.1
46	1.000	-1.1	0.3	-0.3	0.1	-1.1	1.2	-1.0	-1.1
47	1.000	2.6	2.1	1.4	1.5	-1.1	-1.9	1.6	-0.3
48	1.000	-1.1	-1.4	-1.2	-1.4	0.2	-0.4	-1.0	-1.8
49	1.000	-0.2	0.3	0.5	-0.7	-1.1	0.4	-0.4	0.4
50	1.000	0.7	0.3	1.4	0.8	0.2	-0.4	-1.0	-1.8

INVERSE OF CORRELATION MATRIX
----

		afap_lie 85	afai_sm 83	adpi_sm 82	adpp_lie 84	ai_voi_d 32	ai_dep_v 19	ps_vv_tr 46	ps_tc_tr 44
afap_lie	85	3.452227							
afai_sm	83	-1.996121	2.772722						
adpi_sm	82	-0.106005	-0.657330	1.765556					
adpp_lie	84	-1.380683	0.641069	-0.456610	1.840780				
ai_voi_d	32	-0.168410	0.030175	-0.553129	0.086319	1.916044			
ai_dep_v	19	0.156640	0.169345	0.093237	0.082551	-1.151442	1.787074		
ps_vv_tr	46	-0.231280	-0.245913	0.101815	0.187698	-0.164116	0.256640	1.329111	
ps_tc_tr	44	0.239491	-0.286773	-0.030637	0.011719	0.272886	-0.187097	-0.432229	1.231946

SQUARED MULTIPLE CORRELATIONS (SMC) OF
EACH VARIABLE WITH ALL OTHER VARIABLES

85	afap_lie	0.71033
83	afai_sm	0.63934

```
  82 adpi_sm    0.43361
  84 adpp_lie   0.45675
  32 ai_voi_d   0.47809
  19 ai_dep_v   0.44043
  46 ps_vv_tr   0.24762
  44 ps_tc_tr   0.18828


PARTIAL CORRELATIONS
--------------------


             afap_lie afai_sm  adpi_sm  adpp_lie ai_voi_d ai_dep_v ps_vv_tr ps_tc_tr
                  85       83       82       84       32       19       46       44

afap_lie  85    1.000
afai_sm   83    0.645    1.000
adpi_sm   82    0.043    0.297    1.000
adpp_lie  84    0.548   -0.284    0.253    1.000
ai_voi_d  32    0.065   -0.013    0.301   -0.046    1.000
ai_dep_v  19   -0.063   -0.076   -0.052   -0.046    0.622    1.000
ps_vv_tr  46    0.108    0.128   -0.066   -0.120    0.103   -0.167    1.000
ps_tc_tr  44   -0.116    0.155    0.021   -0.008   -0.178    0.126    0.338    1.000

THE ELEMENTS OF THIS MATRIX ARE THE PARTIAL CORRELATIONS
OF EACH PAIR OF VARIABLES, PARTIALED ON ALL OTHER VARIABLES
(I.E., HOLDING ALL OTHER VARIABLES FIXED).


HISTOGRAM OF EIGENVALUES

  EIGENVALUE     HISTOGRAM

  1  2.71264     ****************************************************************************************************
  2  1.79485     ******************************************************************
  3  1.28625     ***********************************************
  4 0.679182     *************************
  5 0.573321     *********************
  6 0.476462     ******************
  7 0.304756     ***********
  8 0.172547     ******

CONDITION NUMBER =    15.72
```

```
COMMUNALITIES OBTAINED FROM  3 FACTORS AFTER    1 ITERATIONS.
-------------------------------------------------------------

THE COMMUNALITY OF A VARIABLE IS ITS SQUARED MULTIPLE
CORRELATION WITH THE FACTORS.

   85 afap_lie    0.8269
   83 afai_sm     0.7323
   82 adpi_sm     0.6514
   84 adpp_lie    0.6298
   32 ai_voi_d    0.8284
   19 ai_dep_v    0.8104
   46 ps_vv_tr    0.6629
   44 ps_tc_tr    0.6518

FACTOR  VARIANCE    CUMULATIVE PROPORTION OF VARIANCE  CARMINES
        EXPLAINED    IN DATA SPACE   IN FACTOR SPACE     THETA
------  ---------   --------------------------------   ------
   1     2.7126          0.3391          0.4682         0.7215
   2     1.7948          0.5634          0.7780
   3     1.2862          0.7242          1.0000
   4     0.6792          0.8091
   5     0.5733          0.8808
   6     0.4765          0.9403
   7     0.3048          0.9784
   8     0.1725          1.0000

THE VARIANCE EXPLAINED BY EACH FACTOR IS THE EIGENVALUE FOR THAT FACTOR.

TOTAL VARIANCE IS DEFINED AS THE SUM OF THE POSITIVE EIGENVALUES OF THE
CORRELATION MATRIX.

UNROTATED FACTOR LOADINGS (PATTERN)
-----------------------------------
FOR PRINCIPAL COMPONENTS


               FACTOR1    FACTOR2    FACTOR3
                     1          2          3

afap_lie  85      0.900     -0.012     -0.131
afai_sm   83      0.835     -0.134      0.128
adpi_sm   82      0.743      0.314      0.004
adpp_lie  84      0.662      0.131     -0.417
```

ai_voi_d	32	0.195	0.811	0.364
ai_dep_v	19	-0.177	0.774	0.424
ps_vv_tr	46	0.359	-0.454	0.573
ps_tc_tr	44	0.125	-0.445	0.662
	VP	2.713	1.795	1.286

THE VP IS THE VARIANCE EXPLAINED BY THE FACTOR.
IT IS COMPUTED AS THE SUM OF SQUARES FOR THE
ELEMENTS OF THE FACTOR'S COLUMN IN THE FACTOR
LOADING MATRIX.

DIRECT OBLIMIN ROTATION, GAMMA = 0.0000

ITERATION	SIMPLICITY CRITERION
0	2.646649
1	1.739448
2	1.070080
3	1.038492
4	1.036146
5	1.036010
6	1.036002

ROTATED FACTOR LOADINGS (PATTERN)

		FACTOR1 1	FACTOR2 2	FACTOR3 3
afap_lie	85	0.898	-0.074	0.076
afai_sm	83	0.753	-0.032	0.346
adpi_sm	82	0.754	0.273	0.009
adpp_lie	84	0.762	-0.115	-0.288
ai_voi_d	32	0.196	0.883	-0.022
ai_dep_v	19	-0.182	0.882	-0.028
ps_vv_tr	46	0.139	-0.056	0.784
ps_tc_tr	44	-0.108	-0.001	0.809
	VP	2.623	1.654	1.478

THE VP IS THE VARIANCE EXPLAINED BY THE FACTOR.

```
IT IS COMPUTED AS THE SUM OF SQUARES FOR THE
ELEMENTS OF THE FACTOR'S COLUMN IN THE FACTOR
LOADING MATRIX.
                                              ROTATED FACTOR LOADINGS

          VARIABLES ARE DENOTED BY 1,..., 9, A,..., Z
          OVERLAPS ARE DENOTED BY AN ASTERISK.

         .+....+....+....+....+....+....+....+....+....+....+.            .+....+....+....+....+....+....+....+....+....+....+.
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
    1.0  +                                                   +       1.0  +                                                   +
         -                                                   -            -                                                   -
         -                    6         5                    -            -                                                   -
         -                                                   -            -                      8     7                      -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
    .50  +                                                   +       .50  +                                                   +
         -                                                   -            -                                                   -
         -                                                   -            -                                            2      -
F        -                                            3      -   F        -                                                   -
A        -                                                   -   A        -                                                   -
C        -                                                   -   C        -                                                   -
T        -                                                   -   T        -                                               1   -
O   0.0  +                      8                     2      +   O   0.0  +                    6         5             3      +
R        -                            7                  1   -   R        -                                                   -
2        -                                            4      -   3        -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                            4      -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
   -.50  +                                                   +      -.50  +                                                   +
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
   -1.0  +                                                   +      -1.0  +                                                   +
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
```

```
         -                                                    -
         .+....+....+....+....+....+....+....+....+....+....+.
        -1.0      -.60      -.20       .20       .60      1.0
             -.80      -.40       0.0       .40       .80

                               FACTOR1
                   ROTATED FACTOR LOADINGS

          VARIABLES ARE DENOTED BY 1,..., 9, A,..., Z
          OVERLAPS ARE DENOTED BY AN ASTERISK.

         .+....+....+....+....+....+....+....+....+....+....+.
         -                                                    -
         -                                                    -
         -                                                    -
         -                                                    -
     1.0 +                                                    +
         -                                                    -
         -                                                    -
         -                         78                         -
         -                                                    -
         -                                                    -
         -                                                    -
     .50 +                                                    +
         -                                                    -
         -                         2                          -
F        -                                                    -
A        -                                                    -
C        -                                                    -
T        -                        1                           -
O    0.0 +                                 3              *   +
R        -                                                    -
3        -                                                    -
         -                                                    -
         -                       4                            -
         -                                                    -
         -                                                    -
    -.50 +                                                    +
         -                                                    -
         -                                                    -
         -                                                    -
         -                                                    -
         -                                                    -
         -                                                    -
```

```
         -                                                    -
         .+....+....+....+....+....+....+....+....+....+....+.
        -1.0      -.60      -.20       .20       .60      1.0
             -.80      -.40       0.0       .40       .80

                               FACTOR1
```

```
-1.0  +                                                    +
      -                                                    -
      -                                                    -
      -                                                    -
      .+....+....+....+....+....+....+....+....+....+....+.
     -1.0      -.60      -.20       .20       .60       1.0
          -.80      -.40       0.0       .40       .80

                          FACTOR2
```

FACTOR CORRELATIONS FOR ROTATED FACTORS

		FACTOR1 1	FACTOR2 2	FACTOR3 3
FACTOR1	1	1.000		
FACTOR2	2	0.020	1.000	
FACTOR3	3	0.085	-0.094	1.000

SORTED ROTATED FACTOR LOADINGS (PATTERN)

		FACTOR1 1	FACTOR2 2	FACTOR3 3
afap_lie	85	0.898	0.000	0.000
adpp_lie	84	0.762	0.000	0.000
adpi_sm	82	0.754	0.000	0.000
afai_sm	83	0.753	0.000	0.346
ai_voi_d	32	0.000	0.883	0.000
ai_dep_v	19	0.000	0.882	0.000
ps_tc_tr	44	0.000	0.000	0.809
ps_vv_tr	46	0.000	0.000	0.784
	VP	2.623	1.654	1.478

THE ABOVE FACTOR LOADING MATRIX HAS BEEN REARRANGED SO
THAT THE COLUMNS APPEAR IN DECREASING ORDER OF VARIANCE
EXPLAINED BY FACTORS. THE ROWS HAVE BEEN REARRANGED

```
SO THAT FOR EACH SUCCESSIVE FACTOR, LOADINGS GREATER
THAN  0.5000 APPEAR FIRST.  LOADINGS LESS THAN  0.3000
HAVE BEEN REPLACED BY ZERO.

ABSOLUTE VALUES OF CORRELATIONS IN SORTED AND SHADED FORM
---------------------------------------------------------

  85 afap_lie *
  84 adpp_lie I*
  82 adpi_sm  I+*
  83 afai_sm  X-I*
  32 ai_voi_d   - *
  19 ai_dep_v .  .I*
  44 ps_tc_tr    .. *
  46 ps_vv_tr .  - .-*




THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME
                LESS THAN OR EQUAL TO        0.123
     .        0.123  TO AND INCLUDING        0.246
     -        0.246  TO AND INCLUDING        0.368
     +        0.368  TO AND INCLUDING        0.491
     I        0.491  TO AND INCLUDING        0.614
     X                   GREATER THAN        0.614

FACTOR SCORE COEFFICIENTS
-------------------------
THESE COEFFICIENTS ARE FOR THE STANDARDIZED VARIABLES,
MEAN ZERO AND STANDARD DEVIATION ONE.


               FACTOR1    FACTOR2    FACTOR3
                     1          2          3

afap_lie  85    0.34186   -0.05066    0.01731
afai_sm   83    0.27626   -0.01589    0.20714
adpi_sm   82    0.28604    0.15858   -0.01307
adpp_lie  84    0.30345   -0.08537   -0.22727
ai_voi_d  32    0.06785    0.53258    0.00396
ai_dep_v  19   -0.07673    0.53505    0.01355
```

```
ps_vv_tr  46    0.02530   -0.01212    0.52716
ps_tc_tr  44   -0.07078    0.02406    0.55507


FACTOR SCORE COVARIANCE (COMPUTED FROM FACTOR
STRUCTURE AND FACTOR SCORE COEFFICIENTS)
---------------------------------------------

THE DIAGONAL OF THE MATRIX BELOW CONTAINS THE SQUARED
MULTIPLE CORRELATIONS OF EACH FACTOR WITH THE VARIABLES.


               FACTOR1    FACTOR2    FACTOR3
                     1          2          3

FACTOR1    1      1.000
FACTOR2    2      0.020      1.000
FACTOR3    3      0.085     -0.094      1.000
ESTIMATED FACTOR SCORES AND MAHALANOBIS DISTANCES (CHI-SQUARE S) FROM
EACH CASE TO THE CENTROID OF ALL CASES FOR THE ORIGINAL DATA
(  8 D.F.) FACTOR SCORES (  3 D.F.) AND THEIR DIFFERENCE (  5 D.F.).
EACH CHI-SQUARE HAS BEEN DIVIDED BY ITS DEGREES OF FREEDOM.
A MINUS SIGN AFTER THE CASE NUMBER DENOTES A CASE WITH NONPOSITIVE WEIGHT.

     CASE     CHISQ/DF CHISQ/DF CHISQ/DF FACTOR1  FACTOR2  FACTOR3
 LABEL   NO.        8        3        5
           1    2.056    0.336    3.088    0.014    0.853   -0.607
           2    1.659    2.037    1.432   -1.110   -1.502   -1.577
           3    1.278    0.116    1.975   -0.302    0.295    0.350
           4    0.984    1.545    0.647   -1.833   -0.521   -1.120
           5    0.709    0.257    0.981   -0.415   -0.744    0.273
           6    1.394    1.235    1.490   -1.464    1.177   -0.568
           7    0.373    0.545    0.270    0.274    0.657   -1.096
           8    1.398    0.405    1.994   -0.769    0.494    0.484
           9    1.383    2.102    0.952   -1.052   -1.532   -1.637
          10    0.575    0.924    0.366    1.402   -0.217   -0.714
          11    0.734    1.137    0.493    1.336    1.299    0.064
          12    1.399    0.959    1.662    0.302   -0.303    1.682
          13    0.913    1.964    0.282    2.408   -0.201    0.407
          14    0.721    1.709    0.128    1.101   -0.228   -1.829
          15    0.722    0.872    0.633   -0.304    1.578   -0.293
          16    0.911    1.116    0.788    0.192    0.276   -1.794
          17    0.927    0.442    1.219    0.308    1.112    0.004
          18    1.248    0.784    1.526   -0.320    0.762    1.177
```

19	1.282	1.197	1.334	0.948	-1.617	0.108
20	0.300	0.359	0.264	-0.085	0.205	-1.032
21	1.146	1.127	1.158	-0.657	1.483	0.637
22	1.148	1.615	0.868	0.747	-1.834	1.166
23	0.884	1.151	0.723	1.080	0.747	1.338
24	1.009	1.930	0.456	1.892	-1.297	0.939
25	0.495	0.163	0.694	0.427	-0.383	0.463
26	0.428	0.271	0.522	0.188	-0.878	0.068
27	0.989	1.507	0.679	0.242	1.304	1.548
28	0.893	0.208	1.304	-0.717	-0.318	0.102
29	0.270	0.072	0.389	0.267	0.199	-0.320
30	1.282	1.450	1.182	-1.627	-1.307	0.253
31	0.603	0.709	0.540	1.029	0.951	0.442
32	1.079	1.608	0.762	-0.498	-1.786	1.310
33	1.025	1.580	0.692	-0.546	1.648	1.084
34	0.454	0.333	0.526	-0.537	-0.064	0.794
35	0.869	1.588	0.438	-1.827	-0.923	0.723
36	0.818	0.130	1.230	0.606	0.109	0.157
37	2.310	1.466	2.816	-0.667	-1.678	1.180
38	0.536	0.607	0.494	-1.058	0.732	0.205
39	0.900	0.633	1.059	-0.356	-0.381	1.273
40	0.990	1.215	0.855	0.381	1.266	-1.461
41	0.547	0.840	0.372	0.575	1.414	0.381
42	0.755	1.184	0.498	0.445	1.214	-1.445
43	0.291	0.321	0.273	0.009	0.378	-0.933
44	0.957	0.376	1.306	-0.486	-0.232	0.889
45	1.577	0.457	2.249	-1.104	-0.122	0.292
46	1.952	0.453	2.852	-0.472	0.013	-1.099
47	1.395	3.091	0.377	2.456	-1.716	0.730
48	0.953	1.342	0.719	-1.389	-0.132	-1.540
49	0.727	0.039	1.139	-0.159	-0.220	0.217
50	0.751	1.493	0.306	1.127	-0.029	-1.675

FACTOR SCORE COVARIANCE (COMPUTED FROM FACTOR SCORES)

		FACTOR1 1	FACTOR2 2	FACTOR3 3
FACTOR1	1	1.000		
FACTOR2	2	0.020	1.000	
FACTOR3	3	0.085	-0.094	1.000

FACTOR SCORES

```
         .+....+....+....+....+....+....+....+....+....+....+.            .+....+....+....+....+....+....+....+....+....+....+.
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
     3   +                                                   +        3   +                                                   +
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
     2   +                                                   +        2   +                                                   +
         -                                                   -            -                                                   -
         -                    1 1                            -            -                           11                      -
         -                    1      1  1                    -            -                     1            1                -
         -             1              21      1              -            -                   1  2        1                   -
     1   +                                  1                +        1   +                    1                    1         +
F        -                1     1  1        1                -   F        -          1          2                       1     -
A        -                           1                       -   A        -                    1                              -
C        -                   1     1                         -   C        -                   1  1      11   1          1     -
T        -                      1 1  2  1                    -   T        -           1    2  1  1 1     1    1               -
O    0   +                     2            1                +   O    0   +                           11        1             +
R        -             1  1    1  1         1  1       1     -   R        -                      1                            -
2        -                   1  1     11                     -   3        -                           1                       -
         -          1                                        -            -             1           1                         -
         -                      1    1                       -            -                                      1            -
    -1   +          1                                        +       -1   +                     1  11 1                       +
         -                                         1         -            -          1                                        -
         -           1                                       -            -                            11                     -
         -                2  1             1                 -            -             1  2                 1                -
         -                     1         1             1     -            -                           1      1                -
    -2   +                                                   +       -2   +                                                   +
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
    -3   +                                                   +       -3   +                                                   +
         -                                                   -            -                                                   -
         -                                                   -            -                                                   -
         .+....+....+....+....+....+....+....+....+....+....+.            .+....+....+....+....+....+....+....+....+....+....+.
        -3.0      -1.8      -.60      .60       1.8       3.0            -3.0      -1.8      -.60      .60       1.8       3.0
             -2.4      -1.2      0.0       1.2       2.4                      -2.4      -1.2      0.0       1.2       2.4
```

```
                               FACTOR1                                                           FACTOR1

                        FACTOR SCORES

         .+....+....+....+....+....+....+....+....+....+....+.
         -                                                   -
         -                                                   -
         -                                                   -
     3   +                                                   +
         -                                                   -
         -                                                   -
         -                                                   -
         -                                                   -
     2   +                                                   +
         -                                                   -
         -                      1             1              -
         -          1                    1                   -
         -          11          1        1                   -
     1   +              1                        1           +
F        -           1     1     11                          -
A        -                                     1             -
C        -                      11   1 1   1   1             -
T        -            1 1    1  111 1    1                   -
O    0   +                  1               1 1              +
R        -                                      1            -
3        -                           1                       -
         -                                1  1               -
         -                       1                           -
    -1   +                         1 11 1                    +
         -                     1                             -
         -                                   11              -
         -            2           11                         -
         -                       1   1                       -
    -2   +                                                   +
         -                                                   -
         -                                                   -
         -                                                   -
         -                                                   -
    -3   +                                                   +
         -                                                   -
         -                                                   -
         .+....+....+....+....+....+....+....+....+....+....+.
```

```
        -3.0      -1.8      -.60       .60       1.8       3.0
             -2.4      -1.2       0.0       1.2       2.4

                                FACTOR2
```

SCALE EVALUATION

ROTATED SECOND-ORDER FACTORS CALCULATED FROM THE MATRIX OF FACTOR CORRELATIONS

		2ND-ORDR 1	2ND-ORDR 2
FACTOR1	1	0.122	0.886
FACTOR2	2	0.850	0.221
FACTOR3	3	-0.586	0.474
	VP	1.081	1.058

THE VP IS THE VARIANCE EXPLAINED BY THE FACTOR. A SINGLE SECOND-ORDER FACTOR WITH A LARGE VP IMPLIES THAT THE FACTORS SHARE COMMON VARIANCE. THIS IS AN INDICATION OF OVERLAPPING DIMENSIONS THAT CONTRIBUTE TO A SINGLE OVERALL DIMENSION. FACTOR ROTATION IS DONE BY THE DIRECT QUARTIMIN METHOD.

NUMBER OF INTEGER WORDS USED IN PRECEDING   PROBLEM   3562

/ FINISH

PROGRAM TERMINATED

Appendix III – Normality study for variables used on the Study 2

Ought to remember that the criteria used on this thesis to assume the normality of the variables was that Skewness and Kurtosis values had to be between -1.5 and +1.5 and present a z-score lower than 1.96.

Table 67 – Expected and actual outcomes Skewness and Kurtosis values

	Variables		Skewness	S.E.	Z-score	Kurtosis	S.E	Z-score
Expectation and actual outcomes	Usm_fccm	SMARTMOOV' will be a facilitator towards a change in my behavior mobility	.16	.35	.46	-.48	.69	.69
	UsmfccmP	SMARTMOOV' has facilitated a change in my behavior mobility	.44	.35	1.25	-1.24	.69	-1.80
	iccm_sm	I feel an incentive to change my mobility behavior due to the use of SMARTMOOV '	.00	.35	.00	-.62	.69	.90
	iccmsmP	I felt an incentive to change my mobility behavior due to the use of SMARTMOOV '	.65	.35	1.85	-.68	.69	.99
	agr_sm	I expect to gain time thanks to SMARTMOOV '	-.51	.34	1.51	-.04	.66	.06
	sm_gt	I gained time thanks to SMARTMOOV '	.21	.35	.59	-1.24	.69	-1.81
	env_sm	Mean value of three statements related with limit the environment impact of mobility	-.66	.35	1.88	-.29	.69	.43
	sm_lie	SMARTMOOV' has helped me to reduce the environmental impact of my travels	.82	.35	2.36	-.22	.69	.31

Table 68 – Traveller intentions Skewness and Kurtosis values

	Variables		Skewness	S.E.	Z-scores	Kurtosis	S.E	Z-scores
Travel Intentions	i_ch_hat	I intend to change my transport habits	.55	.35	1.57	-.49	.69	-.72
	ich_hatP	I intend to change my transporthabits	.38	.35	1.07	-1.02	.69	-1.48
	ps_tc_tr	I would use the TC more often if I had real-time information on timetables and passes	-.40	.34	-1.19	-1.13	.66	-1.70
	pstc_trP	I would use the TC more often if I had real-time information on timetables and passes	.08	.35	.24	-.92	.69	-1.34
	ps_vv_tr	I would use Vélo'v more often if I had real-time information on the availability of Vélo'v and occupation sites	.47	.34	1.39	-1.25	.66	-1.89
	psvv_trP	I would use Vélo'v more often if I had real-time information on the availability of Vélo'v and occupation sites	.72	.35	2.04	-.77	.69	-1.12
	ps_co_tr	I would use the carpool more often if I had a real-time information on the availability offers and demands carpool	-.11	.34	-.31	-1.42	.66	-2.14
	psco_trP	I would use the carpool more often if I had a real-time information on the availability offers and demands carpool	.26	.35	.73	-1.31	.69	-1.90
	ps_vo_it	I would use my car more often if I had real-time traffic information	.28	.34	.82	-1.35	.66	-2.04
	psvo_itP	I would use my car more often if I had real-time traffic information	.93	.35	2.67	.46	.69	.67
	ai_voi_d	I love driving my most frequent travel	.22	.34	.65	-1.40	.66	-2.12

	ai_voiP	I love driving my most frequent travel	.07	.35	.21	-1.45	.69	-2.11
	ai_tcl_d	I love riding PT for my most frequent travel	.30	.34	.90	-1.20	.66	-1.81
	ai_tclP	I love riding PT for my most frequent travel	.37	.35	1.06	-1.16	.69	-1.68
	ai_vel_d	I love biking for my most frequent travel	1.31	.34	3.90	.64	.66	.97
	ai_velP	I love biking for my most frequent travel	1.51	.35	4.33	1.15	.69	1.68
	ai_map_d	I love walking for my most frequent travel	.55	.34	1.62	-.83	.66	-1.25
	ai_mapP	I love walking for my most frequent travel	.59	.35	1.69	-.68	.69	-.99
	ai_cov_d	I love to carpool for my most frequent travel	.55	.34	1.63	-.81	.66	-1.22
	ai_covP	I love to carpool for my most frequent travel	.51	.35	1.46	-.70	.69	-1.02

Table 69 – Effects on traveller behaviour Skewness and Kurtosis values

		Variables		Skewness	S.E.	Z-scores	Kurtosis	S.E	Z-scores
Effects on travel behaviour	Autumn/Winter	AHLV_voi	AUTUMN-WINTER. MONDAY TO FRIDAY:Car	-.64	.34	-1.90	-1.15	.66	-1.74
		AHLVvoiP	AUTUMN-WINTER. MONDAY TO FRIDAY: Car	-.82	.35	-2.33	-.92	.69	-1.33
		AHLV_tc	AUTUMN-WINTER. MONDAY TO FRIDAY: Public transport	.10	.34	.29	-1.76	.66	-2.66
		AHLVtcP	AUTUMN-WINTER. MONDAY TO FRIDAY: Public transport	.38	.35	1.08	-1.61	.69	-2.35
		AHLV_drm	AUTUMN-WINTER. MONDAY TO FRIDAY: Two-wheeled motor	4.84	.34	14.38	22.33	.66	33.74
		AHLVdrmP	AUTUMN-WINTER. MONDAY TO FRIDAY: Two-wheeled motor	3.89	.35	11.11	15.07	.69	21.91
		AHLV_ter	AUTUMN-WINTER. MONDAY TO FRIDAY: TER	4.64	.34	13.78	22.60	.66	34.14
		AHLVterP	AUTUMN-WINTER. MONDAY TO FRIDAY: TER	3.78	.35	10.79	14.92	.69	21.69
		AHLV_map	AUTUMN-WINTER. MONDAY TO FRIDAY: Walking exclusively	.70	.34	2.08	-.83	.66	-1.26
		AHLVmapP	AUTUMN-WINTER. MONDAY TO FRIDAY: Walking exclusively	.27	.35	.77	-1.37	.69	-1.99
		AHLV_vep	AUTUMN-WINTER. MONDAY TO FRIDAY: Bike	3.05	.34	9.05	9.74	.66	14.71
		AHLVvepP	AUTUMN-WINTER. MONDAY TO FRIDAY: Bike	1.93	.35	5.52	3.25	.69	4.72
		AHLV_vev	AUTUMN-WINTER. MONDAY TO FRIDAY: Velo'v	3.16	.34	9.40	8.93	.66	13.49
		AHLVvevP	AUTUMN-WINTER. MONDAY TO FRIDAY: Velo'v	4.22	.35	12.04	20.15	.69	29.30
		AHLV_tro	AUTUMN-WINTER. MONDAY TO FRIDAY: Trottinette or rollerblade	5.60	.34	16.63	32.44	.66	49.01
		AHLVtroP	AUTUMN-WINTER. MONDAY TO FRIDAY: Trottinette or rollerblade	4.63	.35	13.22	20.32	.69	29.54
	Spring/Summer	PELV_voi	IN SPRING-SUMMER. MONDAY TO FRIDAY: Car	-.45	.34	-1.34	-1.36	.66	-2.05
		PELVvoiP	IN SPRING-SUMMER. MONDAY TO FRIDAY: Car	-.28	.35	-.80	-1.49	.69	-2.17
		PELV_tc	IN SPRING-SUMMER. MONDAY TO FRIDAY: Public Transport	.18	.34	.53	-1.49	.66	-2.25
		PELVtcP	IN SPRING-SUMMER. MONDAY TO FRIDAY: Public Transport	.20	.35	.58	-1.60	.69	-2.32
		PELV_drm	IN SPRING-SUMMER. MONDAY TO FRIDAY: Two-wheeled motor	3.37	.34	10.02	10.69	.66	16.15
		PELVdrmP	IN SPRING-SUMMER. MONDAY TO FRIDAY: Two-wheeled motor	3.53	.35	10.08	11.14	.69	16.20
		PELV_ter	IN SPRING-SUMMER. MONDAY TO FRIDAY: TER	4.64	.34	13.78	22.60	.66	34.14
		PELVterP	IN SPRING-SUMMER. MONDAY TO FRIDAY: TER	3.78	.35	10.79	14.92	.69	21.69
		PELV_map	IN SPRING-SUMMER. MONDAY TO FRIDAY: Walking exclusively	.31	.34	.92	-1.57	.66	-2.37
		PELVmapP	IN SPRING-SUMMER. MONDAY	-.11	.35	-.33	-1.55	.69	-2.26

		TO FRIDAY: Walking exclusively						
	PELV_vep	IN SPRING-SUMMER. MONDAY TO FRIDAY: Bike	1.39	.34	4.12	.24	.66	.37
	PELVvepP	IN SPRING-SUMMER. MONDAY TO FRIDAY: Bike	1.19	.35	3.40	-.21	.69	-.30
	PELV_vev	IN SPRING-SUMMER. MONDAY TO FRIDAY: Velo'v	3.04	.34	9.04	9.21	.66	13.91
	PELVvevP	IN SPRING-SUMMER. MONDAY TO FRIDAY: Velo'v	2.98	.35	8.53	8.14	.69	11.84
	PELV_tro	IN SPRING-SUMMER. MONDAY TO FRIDAY: Trottinette or rollerblade	3.45	.34	10.25	12.38	.66	18.70
	PELVtroP	IN SPRING-SUMMER. MONDAY TO FRIDAY: Trottinette or rollerblade	4.63	.35	13.22	20.32	.69	29.54
Weekends	HWE_voi	USUALLY during WEEKEND: Car	-.71	.34	-2.10	-.83	.66	-1.25
	HWEvoiP	USUALLY during WEEKEND: Car	-.76	.35	-2.18	-.56	.69	-0.82
	HWE_tc	USUALLY during WEEKEND: Public Transport	.72	.34	2.13	-.70	.66	-1.06
	HWEtcP	USUALLY during WEEKEND: Public Transport	1.16	.35	3.31	.61	.69	.89
	HWE_drm	USUALLY during WEEKEND: Two-wheeled motor	3.78	.34	11.22	16.16	.66	24.42
	HWEdrmP	USUALLY during WEEKEND: Two-wheeled motor	3.26	.35	9.30	9.49	.69	13.80
	HWE_ter	USUALLY during WEEKEND: TER	7.07	.34	21.01	50.00	.66	75.54
	HWEterP	USUALLY during WEEKEND: TER	Constant					
	HWE_map	USUALLY during WEEKEND: Walking exclusively	.41	.34	1.22	-1.14	.66	-1.73
	HWEmapP	USUALLY during WEEKEND: Walking exclusively	.68	.35	1.93	-.88	.69	-1.29
	HWE_vep	USUALLY during WEEKEND: Bike	1.63	.34	4.83	1.67	.66	2.53
	HWEvepP	USUALLY during WEEKEND: Bike	1.42	.35	4.04	.58	.68	.84
	HWE_vev	USUALLY during WEEKEND: Velo'v	3.29	.34	9.77	11.06	.66	16.71
	HWEvevP	USUALLY during WEEKEND: Velo'v	4.00	.35	11.42	18.52	.69	26.93
	HWE_tro	USUALLY during WEEKEND: Trottinette or rollerblade	4.24	.34	12.59	17.29	.66	26.13
	HWEtroP	USUALLY during WEEKEND: Trottinette or rollerblade	6.78	.35	19.37	46.00	.69	66.90

Table 70 –Smartmoov’ usage Skewness and Kurtosis values

Variables			Skewness	S.E.	Z-scores	Kurtosis	S.E	Z-scores
Smartmoov' usage	ipdo_sm	I intend to use SMARTMOOV’ to plan my occasional trips	-1.13	.35	-3.24	-.12	.69	-.81
	ipdo_smP	I used SMARTMOOV 'plan for my occasional trips	-.74	.35	-2.11	-.42	.69	-1.11
	pdp_sm	I intend to use SMARTMOOV’ to plan my daily commute	-.89	.35	-2.55	-.26	.69	-.95
	ipdp_smP	I used SMARTMOOV 'to plan my daily commute	-.22	.35	-.64	.09	.69	-.60
	cur_sm	I'm curious about SMARTMOOV’	-1.88	.35	-5.36	-1.44	.69	-2.13
	cur_smP	I was curious to use SMARTMOOV '	1.44	.35	4.12	2.64	.69	1.95

Table 71 –Willingness to pay Skewness and Kurtosis values

Variables			Skewness	S.E.	Z-scores	Kurtosis	S.E	Z-scores
Willing to pay	payer_sm	I'm ready to pay to use SMARTMOOV'	1.25	.35	3.56	1.53	0.69	2.22
	payer_smP	I'm ready to pay to use SMARTMOOV'	1.68	.35	4.80	2.66	0.69	3.87

Table 72 –Skewness and Kurtosis values

	Variables	Skewness	S.E.	Z-scores	Kurtosis	S.E	Z-scores
pdq_sm	I think I will have to face different problems using SMARTMOOV' daily	.71	.35	2.03	-.55	.69	-1.24
pdp_smP	I faced various problems using SMARTMOOV 'daily	-.56	.35	-1.61	-.56	.69	-1.25
a_appfac	I expect to have an easy to use app	-1.54	.35	-4.40	2.41	.69	1.72
sm_fac	SMARTMOOV' is an easy to use app	.06	.35	.17	.79	.69	.10

Table 73 - TPB constructs Skewness and Kurtosis values

	Variables	Skewness	S.E.	Z-scores	Kurtosis	S.E	Z-scores
SN	Subjective norms Ex_ante	.208	.337	.617	-.028	.662	-.042
SN_A	Subjective norms Ex_post	2.782	.350	7.949	11.525	.688	16.751
PBC	Perceived Behaviour control Ex_ante	-.196	.337	-.582	-.917	.662	-1.385
PBC_A	Perceived Behaviour control Ex_post	.559	.350	1.597	-.472	.688	-.686
ATT	Attitudes towards behaviour Ex_ante	.088	.337	.261	-.941	.662	-1.421
ATT_A	Attitudes towards behaviour Ex_post	-.061	.350	-.174	-1.042	.688	-1.515